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THE

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SKETCH OF THE LIFE AND WORK OF CHARLES BAKER ADAMS.

By HENRY M. SEELY, Middlebury, Vt.

PORTRAIT—PLATE I.

Amherst College was greatly honored by the men that graduated in the class of 1834. A member of this class in later years said something very like this: "We led our class, you at one end and I at the other." This playful recognition by Henry Ward Beecher of the superior scholarship of a loved and loving friend and classmate must not be taken too seriously for the great preacher himself was no mean scholar in rhetoric and kindred studies. But whoever was the trailer evidently there was a leader of this class of eminent men. The name of this leader stands as the title of this sketch.

Charles Baker Adams was the son of Charles Jeremiah, and Hannah Baker Adams. His birthplace was Dorchester, Mass., the time of his birth January 11, 1814. He was fortunate in many respects, particularly in ancestry, in surroundings, in taste, and in training.

The father, Charles Jeremiah, was a Boston merchant born at Medfield, Mass., 1789, and of that kind of stock that made the family name Adams famous.

It is not always possible to say what a man is worth, the sum having a sliding scale from the minus of a pauper or the lower down minus of a criminal, to the plus high power of a president of the United States. When Henry Adams stepped out on the landing place at Salem near 1632 there went with him unseen potentialities the value of which one can hardly overestimate. No bound or recoil answered the footfall of this man as he walked forth into the new world to which he was

bringing his energies. But later all America became responsive to it. Through his descendents he became a large factor in shaping the fortunes of this new world. The family name runs along the early and later pages of American history.

From the labors of an immediate ancestor of Charles Jeremiah has come mostly what is known of the early relationships of the family, he having compiled the first known genealogical record of the family in this country, threading almost untrodden regions on horseback for the purpose.

Charles Baker Adams was in the seventh generation of the American family, having come down through lieutenant Henry Adams the oldest son of Henry Adams the immigrant.

This founder of the family settled in Braintree, Mass., and here was gathered a household of eight sons and one daughter Ursula. The names of the sons were Henry, Thomas, Samuel, Jonathan, Peter, John, Joseph, and Edward. These children he had probably brought with him from England.

Henry, the oldest son, was the first town clerk of Braintree and the first record of a marriage was that of himself with Elizabeth Payne, November 17, 1643. The second marriage entry was that of his brother Joseph and Hannah Baxter. These were the great grandparents of John, the future president, as well as of the second cousin, Samuel, the revolutionary patriot and state governor.

A paragraph giving the genealogy of Charles Baker and incidentally at the same time showing the size of families of earlier times will be interesting. Henry Adams 1st, eight sons and one daughter; Henry 2nd, seven sons and one daughter; Henry 3rd, three sons and four daughters; Henry 4th, four sons and seven daughters; Elijah, eight sons and eight daughters; Charles Jeremiah, two sons; Charles Baker, five sons and one daughter.

Near the time Henry 2nd made the record of the marriage of his brother Joseph he removed from Braintree to Medfield and was the first town clerk of Medfield. Here his branch of the Adams family became numerous and distinguished, and here Charles Jeremiah was born.

It would be interesting to know something of the pursuits of the lad Charles Baker, of his friends and associates in his Dorchester home, but the years have gone by without record

or remembrance further than that he was early inclined toward natural history, "fond of bugs," as was said of him.

His tastes led him away from the mercantile pursuits of his father and pointed him towards the life of a scholar. From Dorchester he went to Phillips Academy at Andover and in 1830 entered the freshman class at Yale. The next year, 1831, he entered Amherst College and graduated with the class of 1834.

The college curriculum of the day was thought to be a well rounded one, framed by the experience of renowned educators of both the old world and the new, designed to give a complete scholarship. It was not the purpose to fit a young man for a special profession but rather to ground him in the principles that might be needed in any of what were then the learned professions. So young Adams had the full benefit of training in ancient languages, mathematics, mental and moral science, and whatever of natural science was then taught. In many ways this was a good course. It was strong meat for strong men. Adams took well to this nourishment and grew on it. His diligence with his endowment enabled him to forge forward in scholarship and his scholarship placed him at the head of his class.

The wide world opened before the graduate, but apparently the young man was not quite sure where his field lay. It might be that of theology so he turned his steps towards the Theological Seminary at Andover. Here he spent the first two years of his post graduate life.

In 1836 he was tutor at Amherst College and during the year gave a course of lectures on geology at Bradford Academy, and assisted president Hitchcock for a brief time in a geological survey in New York state.

In 1838 he was called to Middlebury College, Vermont, to take the professorship of chemistry and natural history. While occupying this roomy chair and doing all the exacting work connected with it, he in some way found time for creating a cabinet of natural history which under his diligent hand grew to symmetrical proportions.

The rocks of the state, the minerals at hand and far away, the insects of the surrounding country, many of the vertebrates and especially the mollusks from foreign waters, as well

as a complete suite from the state were collected and here systematized in this museum.

While professor Adams was busy with the large work to which he had set himself, the blooming time of early state geological surveys had come. The studies and lectures of professor Amos Eaton, had had a widely beneficient influence. His labors with those of others created at that time a great wave of geological enthusiasm. The people of the various states became wonderfully interested in the rocks and minerals of their lands, and this interest brought about by legislative action the organization of state surveys. The subject of a state geological survey had been brought before the legislature of Vermont as early as 1836. In and out the legislature the matter was discussed until 1844, when late in October of that year a statute was enacted making an annual appropriation for the three succeeding years for a geological survey.

Early in the spring of 1845 governor William Slade in whose hands the selection of the head of the survey was placed, appointed as such head professor Charles B. Adams.

Professor Adams who had had preliminary training and experience under his college professor Edward Hitchcock, entered at once upon the work assigned him. He was fortunate in the choice of his assistants. He called to his aid professor Zadock Thompson of Burlington who years later became successor in the work of the survey, and Rev. S. R. Hall of Craftsbury, who had chief oversight of the agricultural features of the survey; Denison Olmstead, Jr., and later T. Sterry Hunt gave help in mineralogy and chemistry. Also volunteer and temporary assistants gave excellent help. The state was taken under general survey. According to the directions of the governor, seven suites of specimens were to be assembled for the state; an eighth was to remain in the hands of the principal of the survey, to be disposed of by him at his discretion. The complete suite was for the state collection; the less complete were to be placed in the cabinets of various schools in the state.

Much preliminary work was done the first year of the survey. The personal work of the principal was directed to ascertaining the character and limits of the geological formations. Six thousand specimens were collected and a first an-

nual report on the Geology of the State of Vermont, a paper of 92 pages, was presented.

A busy year, that of 1846, followed. A map of the surface rocks was projected, several sections were worked out, all the counties of the state were visited and in some cases revisited, drawings for future illustrations made, specimens of fossils, rocks, and minerals, were collected, bringing up the number to 12000, and a second annual report, a work of 267 pages was presented.

This second report contained besides much other matter, a brief treatise on geology, for the instruction of the people of the state, with illustrations from the rocks of the state, prepared by the principal of the survey. A careful, comprehensive statement of the economical geology and mineralogy as well as the agricultural features of the state was made.

The results of a collection of sixty samples of soil by S. R. Hall, the altitudes of the mountains of the state by Zadock Thompson, and analyses of rocks and minerals by Denison Olmstead, Jr., were put on record.

A third annual report, that for the year 1847, was briefer, a paper of 32 pages. In it the work of the year is sketched though not largely. Careful sections from lake Champlain to the Green mountains had been carefully worked out by the chief of the survey, the geological map continued and corrected; 3000 specimens had been added to the previous collections. The collection—that for the state now numbering 2000 specimens—had been ticketed with number, formation and locality, and made ready for distribution among the institutions to which they were assigned. The assistants on the survey had been diligent. T. Sterry Hunt had reported the analyses assigned him. The principal had had the deep satisfaction of the presence of professor Desor and professor Agassiz for a little time, and at Burlington and vicinity he had their suggestions in regard to the drift of Vermont.

The work of the three years had been leading up to the preparation of a final report. At the close of the third report professor Adams made estimates, very moderate estimates, for each of the two years required for making out the results of the geological survey.

Near the close he had previously said: "The remainder of the winter will be occupied in collating the field notes and in

making the necessary plans for the preparation of the final report. . . ."

"The time and funds provided by the bill for the geological survey will be exhausted on the first of March, 1848, and additional funds and time will be necessary for making out the results of the survey. In the annual reports but a small part of these results has been given and this has been done in a disconnected way. If we may be allowed a familiar illustration the process of the geological survey thus far has consisted in finding and bringing together the various materials which are yet to be used in the construction of the edifice. Some benefits we hope have already resulted from the survey, but it still remains to make it a source of permanent utility."

But to the loss of the state of Vermont, and perhaps a greater loss to the science of geology the master builder who had so carefully and so laboriously selected the material, was not permitted to build into a harmonious whole the edifice so wisely planned.

Professor Adams, in the last year of the survey, 1847, had accepted a position outside of the state, a professorship at his Alma Mater, Amherst College, Mass.

The state legislature at its succeeding session neglected to make an appropriation for this work. The cause of this failure is not at this day quite clear. It may in great probability be attributed to the absence from the legislative body of those members who early were the advocates and supporters of the survey.

The work stopped. Professor Adams issued a thin fourth report now exceedingly scarce, the mere shade of the final report which was so near his hand.

The results of this period of three years' work may be partly summarized in the following statements. There was exhibited an eminent example of a careful systematic geological survey, there were published annual reports of the progress of the work; a map was prepared of the geological formations of the state as these formations were then understood. Labelled collections of rocks, minerals and fossils were placed at Montpelier and with various literary and medical schools of the state, a mass of geological notes was accumulated. These last, however, were made in a private shorthand and not readily deciphered except by the one who had made them.

Near this time professor Adams in connection with his friend and Amherst classmate professor Alonzo Gray published a text book, Elements of Geology. A person familiar with his annual reports, recognizes that in illustration and in thoughts this book is the outcome of his geological work in Vermont.

The deepening of the groove that professor Adams was impressing on the science of geology apparently stopped here. A suggestion as to the possible cause for his turning abruptly aside from contributing to geology is that he found in his new college associations one whom he looked upon as a master in the science, his old teacher president Hitchcock. With him he would not enter into competition. Whatever may have been the cause, he turned easily to another and a much loved field that was awaiting him, that of zoology. This he entered with the same enthusiasm that had characterized his work in Middlebury, and the wider border, the mountains and valleys of Vermont. Here at Amherst as at Middlebury be put his fashioning hand on the Museum of Natural History to which he transmitted his personal collections accumulated in the Vermont survey.

His more especial original study was in connection with the class Mollusca. The shells of Central America and the West Indies received his careful attention, and in pursuance of his object he made thither successive voyages. He visited Jamaica in 1844-45 and again in 1848-49. Panama, 1850-51, and St. Thomas, 1853-54.

In some parts of his work Thomas Bland, Esq., an English lawyer of New York City, and resident of Brooklyn, was in connection with him, and later Robert Swift a merchant of Philadelphia and St. Thomas.

Frequent published papers came from his study and his pen and between 1849 and 1851 successive contributions to conchology appeared to the number of ten. These had been read before the various scientific societies and were mostly printed in the Annals of the New York Lyceum of Natural History. Various Molluscan collections largely the work of his own hands were examined and catalogs prepared and printed. In April, 1851, there appeared a catalog of the land and fresh water shells that inhabit Jamaica giving a number of land shells, 364, fresh water, 25, in all 389. His great work

in connection with Mollusca was with these forms in and around Jamaica. He hoped to prepare a monograph which should be a complete study of the species and varieties of that region.

From such opportunities for collection and having the gift of making accumulations it is not strange that the Museum under the charge of professor Adams took on a unique character and large proportions. Professor Hovey of the chair of physics had accumulated what may be considered the nucleus for the marvel that crystallized around it. A marvel it was, the hundreds and thousands of specimens grouped as to relationship and bearing a peculiar personality by the labelling in the beautiful handwriting of professor Adams. At the time his formative hand left it, a half century ago, it contained about 8000 species and professor Louis Agassiz said "I do not know in all the country a conchological collection of equal value."

A somewhat similar collection made by Robert Swift, for the sum of $30,000, passed into the keeping of the Smithsonian Institution.

Teaching at Amherst with collecting in the West Indies went on year after year with professor Adams as had his teaching at Middlebury and the geological survey of Vermont.

But the year 1853 was a sad one for Amherst College; an overwhelmingly calamitous one to his family there. While at work at St. Thomas, W. I., he was attacked by the Yellow Fever. He was most faithfully cared for by his colaborer in the conchological field, Robert Swift. But the grip of the fearful malady was too powerful to be loosed by any loving ministration. The strong, the courageous, the hopeful naturalist, yielded his life, dying January 18, 1853, aged thirty-nine years.

Some time later a memorial stone, the appreciative gift of scientific friends, was placed at his grave, the spot at which on St. Thomas his body was buried. So in a way St. Thomas at this early date was pre-empted to the United States, by the deposit of the body of professor Adams, and the erection of the stone that stands sentinel at his dust.

In person Mr. Adams was not large but sturdy, his countenance was that described as intellectual, his eyes large, black, lustrous, his hair abundant and black, early showing of gray. He was a good horseman, a strong swimmer. The sons recall

the incident of the father's gathering the four small boys together at sunrise one summer morning for a stroll with him. He led them a mile away across country to a creek, at the time swollen to a torrent from recent rains. But it seemed to invite the professor who prepared himself for a plunge telling the youngest, a mite of a boy to do the same. Then leading him to the brink, he poising him for a moment in his hands tossed him far out into the current. The little fellow did not cringe or cry, was not afraid, for his father was there. He floated with his head well above the water and when swept down stream turned his eyes expectantly towards his father. The father looking for a little at the wholly trusting boy, dashed headlong into the stream, swam with vigorous strokes until he reached the little waif, when turning his broad back to him, told him to climb up and hold fast. Then such a ride as the boy had! To and fro the strong swimmer went with his small load to the joy of all the party and until the lesson ended.

In demeanor he was quiet and self contained, with a grave cast of countenance. In physical endurance he was tough to a degree, never suffering from lack of sleep, not knowing what it was to be tired. Obstacles in his way he pushed aside, was reckless in the matter of expenditures when such were needed in accomplishing his work. He neither cared for nor feared danger even when, as his friends knew, the peril was great.

An associate of professor Adams speaks of him as a typical scientist, one who possessed a greed of collecting, a remarkable power of classification, an ability to so marshall his individuals and groups that they gave expression to his thoughts. He was diligent, methodical, a tremendous worker. For a little he was brought in company with Agassiz, and one who knew them both thinks, that in brilliancy of intellect he measured up equally with this world renowned naturalist.

In the classroom he had the fullest confidence of his students. Chemistry and natural history were not then the hand to hand sciences between teachers and scholars as today, but the instruction he gave in these departments commanded the careful attention of his listeners. While fast becoming a master in his own realm his work and study were not bounded by special science alone. He was alert to all that was going forward in the world of thought, keeping abreast with the recent

discoveries that were at the time famous. His early scholarship never deserted him and so in emergencies he would for the time assume the chair of Greek or Latin, logic or moral science, to the delight of his classes. The expression "All round scholar" found an exemplification in him.

Quiet humor, laconic speech, and the enjoyment of a happy turn not unfrequently enlivened his class experiences. One or two incidents may show this. The college class of 1842 of Middlebury never forgot one day's exercise. The students, as was the custom of those days, were called on in their turn to recite. When H. M., fleet of tongue but not always careful in his preparation, was called, he went glibly with a long disquisition that had no real relation to the assigned topic, and coming to a halt, the professor quietly said "Not correct." Tacking he again tried his skill in improvising and at length coming to a rest he heard the same words "Not correct." The young man at his wits' end then impulsively exclaimed, "Then I don't know anything about it. " "Correct," instantly from the professor; "Next," and the recitation proceeded—proceeded as well as the electrified condition of the class permitted.

Another incident that has gone into print, rather fantastically dressed, really belongs here. Some of professor Adams' boys at Amherst College did as they thought a nice bit of work, and it was well done. Taking the head of one insect, the mid body of another and the hind body of a third they neatly joined the fragments. Then bringing the triple monstrosity to the professor they confessed their perplexity in regard to the class and name of the object. The professor looked at it a moment then remarked, "Gentlemen this is a hum-bug."

The classroom and laboratory work at Middlebury college must have been exacting yet he found time to make a complete collection of the Mollusca of the state. And this was a small portion of his outside work. The collections illustrating the various branches of zoology in addition to geology and mineralogy, bear evidence of his swift and certain hand. He duplicated and more than duplicated this work at Amherst.

Life was full of promise to himself, his family, and to the scientific world. Near ten years of professional life had been spent in connection with Middlebury college, and half that time with Amherst. With slender help from without he was push-

ing his favorite study when attacked by the fatal malady, which in comparatively early life took him from his chosen field. Science lost a zealous, helpful promoter, when in the early blooming of his powers the promise of great fruitage was sadly and suddenly cut off.

To the family the loss was more than can be told. One son had died in infancy. The wife, four sons and a daughter survived him. In 1839 professor Adams had married Mary Holmes, a woman of strong mental endowments and noble character, the daughter of the Rev. Sylvester Holmes of New Bedford, Mass., and to her care the young household of five children was unexpectedly committed. How these children were trained to honor their father and their father's name, and how they exhibited their loyalty to their country may be learned by a recital of their career. Two of the sons, Charles Breck and Sylvester Holmes, died in 1861, members of the union army in the civil war. Dr. Edward Hitchcock served twelve years in the navy during the latter part of the war of the rebellion and the period of reconstruction that followed, and Henry, the fourth son, was in one of the hundred day regiments made up of men called away from pressing business. And later his grandson Charles Melbourne Atwood, son of his only daughter, Mrs. Lillie Adams Atwood, gave his service and his life in the recent Spanish-American war.

A portrait of professor Adams, the gift of his son Henry, appropriately honors the library of Amherst college. On the shelves and in the cases of both colleges, Middlebury and Amherst, are abiding evidences of his work in the form of suites of Vermont rocks collected during the state geological survey. These with his mineralogical and zoological specimens stand just now at the half century mark, as a memorial of the ability and incessant activity of professor Adams.

He was a member of many societies, chiefly the following:

Association of American Geologists, Boston Society of Natural History, Philadelphia Academy of Natural Science, Lyceum of Natural History of New York, American Academy of Arts and Sciences, Natural History Society of Nuremburg (Corresponding Member), Honorary Member of Jamaica Society.

It may not be possible now to obtain a complete list of the publications of professor Adams, nor can the date and order of appearance be certainly indicated. The greater part, however, will be comprehended under the following titles:

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A SMALL ESKER IN WESTERN NEW YORK.

By Frank M. Comstock, Case School of Applied Science, Cleveland, Ohio.

PLATES II-III.

In Genesee county, New York, there is a small esker of which I made a survey in the summer of 1900. Although a small one, it is such a good example that it seems worthy of record.

This esker is situated partly in the town of Le Roy and partly in the town of Stafford, about half a mile north of the main or State road, and is crossed near its middle by the north and south highway which forms the boundary between the two towns mentioned. It is mainly situated on the so called Snow, Paul, Janes and Bissell farms.

The region in which the esker is located is a kamelike surface with a few low drumlin shaped hills. The esker itself lies one and three-fourths miles south of the ancient Warren shore line as determined by Fairchild (Bul. G. S. A. Vol. 8, p. 31), and some distance south of the corniferous escarpment. It is about three-fourths of a mile long and fifty feet wide at the sur-

FIG. 2.

FIG. 3.

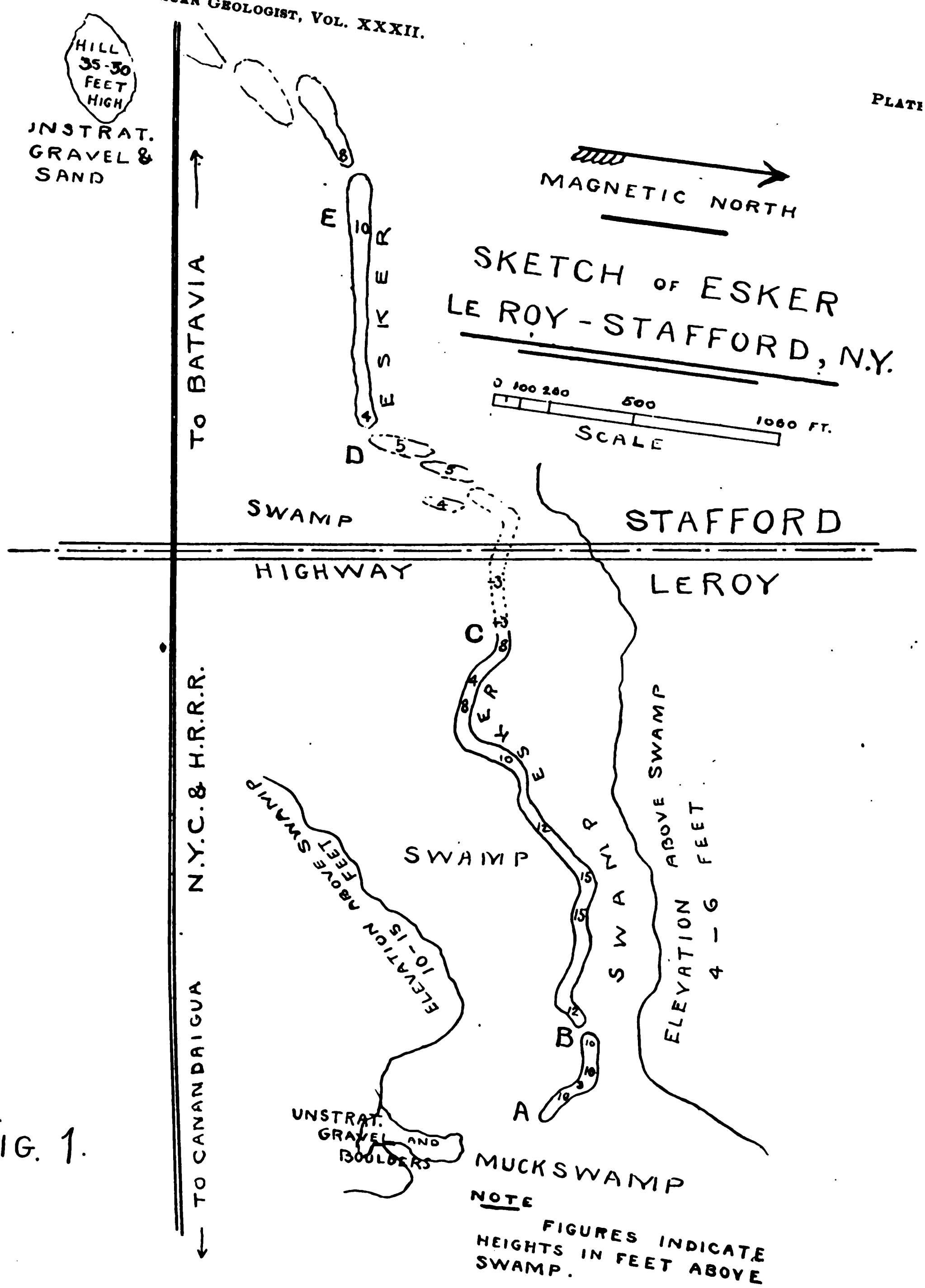
HILL
35-30
FEET
HIGH
UNSTRAT.
GRAVEL &
SAND
MAGNETIC NORTH
SKETCH OF ESKER
LE ROY - STAFFORD, N.Y.
0 100 250 500 1000 FT.
SCALE
TO BATAVIA
ESKER
E
D
C
B
A
SWAMP
HIGHWAY
STAFFORD
LEROY
N.Y.C. & H.R.R.R.
TO CANANDAIGUA
ESKER
SWAMP
SWAMP
ELEVATION 10-15 FEET ABOVE SWAMP
ELEVATION ABOVE SWAMP 4-6 FEET
UNSTRAT.
GRAVEL AND
BOULDERS
MUCKSWAMP
NOTE
FIGURES INDICATE
HEIGHTS IN FEET ABOVE
SWAMP.

FIG. 1.

face of the surrounding ground above which it rises to a hight of some ten or twelve feet.

The ground immediately surrounding the esker is swampy, especially so at the eastern end. Towards the western extremity the ground becomes quite firm and dry. To the north of the esker between A and B (Fig. 1) a few bowlders project above the surface indicating but a slight depth at that point.

Fig. 1, shows a plan of the esker.

Fig. 2, a view along the crest.

Fig. 3, a section near the western end.

As shown in the plan the general direction of the esker is about south 65° west (mag.) being a few degrees more to the west than the glacial striæ in that part of the state. The esker begins (A, Fig. 1), quite abruptly in the swamp, the slope at the end being about the same as at the sides. About four hundred feet west of the beginning, (B, Fig. 1) there is an abrupt break in the formation some twenty feet in extent which now serves for the passage of a farm road. Whether this break is artificial or natural cannot be determined.

At C, an excavation for gravel has removed the esker for some distance, as indicated by the dotted lines on the plan. This disturbance of the original form is continued west of the highway where the esker enters cultivated land and has been much reduced in hight. Near D, the ordinary form of the esker seems to give place to several low mounds two hundred or so feet in length and four or five feet in present hight running nearly north and south. Beyond D the usual form is resumed in uncultivated ground and continues to E, where cultivated land is again entered and the esker is difficult to trace, seeming to be lost in a number of low swells or mounds.

At C, where the esker has been cut away for gravel and sand the section shows immediately below the vegetable mould a layer of stratified sand four feet in thickness interrupted in several places by layers of fine gravel one or two inches thick. Beneath this is a thin whitish layer of sand apparently filled with lime deposit, and below that some six feet of stratified gravel.

Another section some 1500 feet southwest of C is shown in Fig. 3. The material in this portion of the esker seems more sandy than towards the other end and contains a number of cobbles.

A little southeast of where the esker crosses the railroad is a high isolated hill of unstratified gravel and cobbles, while a mile or so to the northwest are a number of drumlin like hills running into true drumlins still further to the northwest.

THE ORIGIN OF OCEAN BASINS ON THE PLANETESSIMAL HYPOTHESIS.*

By T. C. CHAMBERLIN, Chicago, Ill.

The Planetessimal Hypothesis of the origin of the solar system differs fundamentally from the Laplacian and other gaseous hypotheses, and from the meteoroidal hypothesis as set forth by Lockyer and Darwin. These latter assign the extension of the parent nebula to the opposed movements, collisions and rebounds of the constituent molecules or meteoroids. The former assigns it to concurrent orbital movement. In the gaseous and meteoroidal hypotheses (as usually understood) the aggregation is the simple work of gravity following a reduction of the oscillatory and colliding action. In the planetessimal hypothesis the aggregation is individual and relatively slow. In the gaseous hypothesis the temperatures are necessarily very high, and the planets are formed by detachments. In the meteoroidal conception of George Darwin, the conditions are practically the same, and in that of Lockyer they differ rather in degree and in detail than in essence. In the planetessimal conception the planets grew up separately by innumerable accretions of infinitessimal planetoids (planetessimals) and the external temperatures were not necessarily high, since the orbits of the planetessimals were normally direct and concurrent and the aggregation came about by overtakes in contradistinction to opposed collisions, and the frequency of these was limited by the concurrent direction of orbital movement.

The purpose of the paper is to outline the hypothetical origin of the ocean basins under the planetessimal theory, to set forth the simple self-selecting process by which they were perpetuated and deepened, and the connection of this was the dynamics of deformation. (30 minutes.)

* Abstract of a paper presented at the Washington (1902) meeting G. S. A.

THE DEVONIAN ERA IN THE OHIO BASIN.

By EDWARD CLAYPOLE.

PART I.

PLATES IV-X.

This paper, in a different and more complete form, received the Walker prize in 1895. It has been thought best, after the most careful consideration, not to longer delay publication, but to make such revision and abridgement as would suit it to the magazine in which, with peculiar fitness, it now appears. The original paper in the form of a monograph, consisted of four chapters, viz.: SILURIA, DEVONIA, PALÆONTOLOGY OF DEVONIA IN APPALACHIA AND A SUMMARY, together with a GEOLOGICAL FORECAST. Of these, Devonia is here presented with certain necessary changes, while the Palæontology is but slightly altered and two other parts are entirely omitted.

In this work we have been guided by the wise counsel of Dr. Theodore B. Comstock, who has given unsparingly of his time and thought. For this aid we wish to express our deepest gratitude. Constant effort was made to avoid changes, but when these were necessary, the original style and form were scrupulously retained.

Pasadena, California, **EDITH J. CLAYPOLE.**
June, 1903. **AGNES M. CLAYPOLE.**

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20. Proceedings of the Acad. of Nat. Sc. of Philada., 1882. "New Crinoids from the Chemung Rocks of New York." H. S. Williams.
21. "On a dark shale below the Devonian Limestones at Rockford, Iowa, with a notice of its fossils." Bulletin of the U. S. G. S., Vol. IV, no. 3. S. Calvin.
22. Proc. of Am. Ass. for Adv. of Sc., 1884. "Geographical and Physical conditions as modifying fossil faunas." H. S. Williams.
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24. "Geological History of the Missouri Palæozoic." Am. Geologist, Dec., 1894. G. C. Broadhead.
25. "On a fauna found at Lime Creek, Iowa." Am. Journal Sci., June, 1883. S. Calvin.
26. Bulletin of the Illinois State Museum, No. 4. "Upper Devonian and Niagara Crinoids." S. A. Miller and W. F. Gurley.
27. "The Geologic History of Missouri." Am. Geologist, Feb., 1805. A. Winslow.
28. Am. Jour. of Science, Feb., 1895. "On the recurrence of Devonian fossils in strata of Carboniferous age." H. S. Williams.
29. American Naturalist, Nov., Dec., 1887. "The Materials of the Appalachians." E. W. Claypole.
30. Am. Naturalist, March, 1885. "Pennsylvania before and after the Elevation of the Appalachians." E. W. Claypole.
31. Proc. of Am. Phil. Soc., 1883, p. 664. "On Pterichthys rugosus." E. W. Claypole.

The palæontologist notes a marked change in crossing over the almost invisible line between Siluria and Devonia. At a single step he passes from the dolomitic, and, in Ohio, the barren limestones of the Lower Helderberg to the abounding life and almost pure calcareous limestones of the Corniferous group. A complete palæozoic break occurs here, but it is rather a change from death to life than from one fauna to another. The cause of this must be sought outside of the state. The Oriskany sandstone of the eastern states there fills the gap.

A. THE CORNIFEROUS LIMESTONE.

In the absence of the Oriskany, the Corniferous limestone is the actual base of the Devonian system in Ohio. It lies as a solid floor below all the other groups. Its main outcrop runs from north to south, from the lake to the river, as shown in map V, and east of this it is continuous over the whole eastern part of the state. It has been found in every drill hole that has been pushed far enough to reach its horizon, and to its great solidity and to the quantity of chert which it contains may be ascribed the sudden stoppage of many of these undertakings.

Aside from this cherty component, the limestone itself does not present any special hardness and is usually included by the driller with the underlying Lower Helderberg, as 600 feet of limestone very hard in the upper part.

In composition, however, the chemist finds a marked diminution in the proportion of magnesia and a relative increase in that of lime. The rock is no longer a dolomyte but is nearer to a normal limestone, as may be seen from the following analyses taken from the "Geology of Ohio."

Lower Helderberg Limestones.		*Corniferous Limestone.*			
Carbonate of Lime	55.97	93.28	Upper.	81.14	Lower
Carbonate of Magnesia	44.27	2.69	"	16.00	"
Silica	———	1.41	"	1.94	"
Vol. VI, p. 354.		Vol. III, p. 936.			

The chert consists for the most part of the casts of fossils, especially of corals, in which the lime has been replaced by silica during mineralization. Sometimes, as at Bellefontaine, this chert has a chalky texture and appearance, but usually it is hard and of various tints from black to white. It was

doubtless one of the sources of the material used by the aborigines in the manufacture of implements and weapons, but was gathered by them mainly from the drift.

Such material indicates in the waters of the Corniferous sea a considerable quantity of silica in solution and possibly a high temperature. The silicification probably began with the death of the organism and proceeded rapidly amid conditions resembling those of the Cretaceous era in Europe, but without the abounding infusorial forms of the latter.

In some parts of the state a flow of salt water has been met at the base of the Corniferous limestone, but in the northeastern counties no such difficulty has been reported and several wells have been sunk to and through it, and for hundreds of feet below it, which have remained perfectly dry. It is probable that, in the former cases, a local bed of the Sylvania or the West Jefferson sands was encountered in which the water was stored, and which was at one time thought to represent the Oriskany.

Local patches of fine white glass-sand occur near the base of the limestone, similar to some found in the uppermost 200 feet of the Silurian series. These sands are remarkable for their purity and sharpness. This Corniferous sandstone outcrops in Jefferson township, Madison county, on the bank of Little Darby creek, and there is every reason to believe that other pockets of it will be found in the vicinity. "It has long been known to the plasterers of the neighborhood. Whenever the finest quality of work was required, recourse was had to the thin layers of sandstone found in this section."*

"The sandstone is nowhere more than six inches thick and it lies between ledges of rock so heavy that it cannot be profitably obtained except when the quarry is worked for other purposes."

Deposits of a similar sandstone are also found in Madison and in Logan counties.† The comparatively unworn appearance of the crystals of these sandstones, their small extent and their singular occurrence in the midst of solid sheets of limestone of almost continental area, argue for them an origin different from that of most sandstones.

* *Geology of Ohio*, vol. iii, p. 615.

* *Ibid.*, p. 422.

Though these beds lie approximately on the margin of the Silurian and Devonian domains, they cannot be regarded as a dividing horizon, inasmuch as they occur through several hundred feet of strata, part of which lies in one system and part in the other. But on Big Darby creek, near Georgesville, a series of red and white clays is found, which apparently lies just on the parting plane, and which, if not of secondary origin, may be taken as locally, at least, forming a Siluro-Devonian frontier line.

Besides the main outcrop another and a shorter one occurs on the western side of the Cincinnati arch, extending from the lake to the Indiana state-line. Along this line, however, the surface is so deeply covered with drift deposits that the underlying strata can be seen only in a few places.

Thickness and Section.—The whole thickness usually assigned to the Corniferous limestone in Ohio is about seventy-five feet, but nowhere does the whole of this appear continuously. The most nearly complete section which has been described is that shown in the northeastern part of Franklin county, along the Scioto river, near Dublin. The following account is condensed from the Geology of Ohio.*

"At the base of the section, on a level with the water and probably about ten feet above the top of the Corniferous limestone, is a bed of cutting stone about ten feet thick. and over this lie five feet of thinner beds four or five inches thick, two of which hold flint concretions with such fossils as *Murchisonia, Loxonema, and Pleurotomaria.* Then follow nineteen feet of thin white limestones, crowded with fossils, which furnish good building stone and a strong white lime. These are the Delhi beds (in part) of Prof. N. H. Winchell. Eleven feet of shaly limestone follow, the upper Delhi beds of the same author, having little economic value and capped by a very thin but remarkable four-inch layer called the "Bone-bed," composed more or less, and often in great part, of the fossil teeth and other parts of fishes, chiefly of the genus *Onychodus,* whose sigmoid teeth are not infrequently found in the mass of fragments. This stratum extends through the formation wherever shown in Franklin county, but only in a limited area does it present all its points of interest. Elsewhere scarcely a square foot can be found which does not contain some fragment of a tooth or plate, but here these remains make up the substance of the bed."

The strata beneath the Bone-bed constitute what was called by Dr. Newberry the Columbus limestone.† They form the

* Vol. iii, pp. 605-611.
Geology of Ohio, vol. i, p. 143.

lower portion of the Corniferous group as defined in the same work and reach in all a thickness of forty-five feet.

Above this well marked horizon is found a series of thin and shaly beds known as blue limestones and for the most part of little economic value. They are about thirty-two feet thick, fossiliferous in the lower part with the fish remains of the Bone-bed, but barren and flinty above. "Their upper boundary is as distinct as their lower, consisting of the blue shales that make the base of the great system of Devonian shales. These constitute the Delaware limestone of professor Winchell, or the Upper section of the Corniferous limestone of the Geology of Ohio."*

Corniferous Geography.—Two lines of outcrop of the Corniferous exist in the state caused by the elevation of the Cincinnati anticline. Beginning with the longer of these, which crosses the state from lake Erie to Pickaway county, we find its northern extremity in the two islands, Kelly and Middle, the former of which is a part of Erie county, Ohio, while the latter belongs to Ontario, Canada. On Kelly's island, the Lower Corniferous has long been quarried to supply a flux for the furnaces of northern Ohio, for which this stone has proved exceedingly well adapted.

The peninsula in Sandusky county, is the most northerly exposure of the Corniferous limestone on the mainland along this line. The easternmost point of Ottawa county defends, with the northernmost part of Erie county, the entrance to Sandusky bay. The upper blue-stone transition beds are largely quarried at Sandusky, but the lower, or true Corniferous lies too deep to be reached. Crossing Erie county and touching the northwestern corner of Huron county and the southeastern corner of Sandusky county, the outcrop enters Seneca county, where it is but slightly exposed in spite of the large area which it underlies. In eastern Crawford county and western Wyandot county the same is true. The surface is covered with drift, the exposures are few and little quarrying is done except along Broken Sword creek. In Marion county, however, about twelve feet of the blue transition beds are quarried near the county seat, while in Delaware county, along the Olentangy, one of the best sections in the state is displayed

* *Ibid.*, p. 606.

and very extensive excavations have been made, especially along the river and in the upper beds. The full thickness of 110 feet is assigned to it here, that is, thirty-five feet to the upper and seventy-five feet to the lower portion.

Slightly touching Madison county, the outcrop runs into Franklin county, occupying its western half and showing, along the Scioto, near Dublin and the capital city, some of the finest exposures and largest quarries along the whole line.

Then, with a long rounded projection into Pickaway county, the outcrop comes to an end, being overlapped by the Black shale, which there stretches to the westward beyond the meridian of the Corniferous limestone. Nor does evidence derived through the drill, as at Lancaster, Jackson and Ironton, give any proof of its continuance under cover to the southward, so that it probably runs no farther in that direction. Its apparent thinning and its absence in a large area, if not altogether, in northern Kentucky, according to Shaler,* are additional support of this opinion.

Coming back to the second line of outcrop, we find the Corniferous limestone entering the state from Michigan, in Lucas county, and continuing through Wood, Henry, Defiance, Putnam and Paulding counties to the Indiana state line. Exposures are so rare, owing to the deep covering of drift, that no data of importance are afforded thereby.

Beyond the state line the Corniferous limestone is nowhere seen on the surface and has been nowhere reached by the drill to the south of this latitude, nor throughout the Appalachian region, until it reappears in northeastern Pennsylvania after an interval of nearly five hundred miles. Here it is thin but rapidly thickens up to 200 feet or more,† and in New York it is reported of even greater thickness. Through that state it can be traced in a northerly direction to Albany, where it turns to the west, crosses the state and runs into Ontario county, continuing with its usual characters half way along the north shore of the lake. Here a thickness of 160 feet is assigned to it.‡ Curving to the north, it passes under lake Huron and reappears in northern Michigan, where A. Winchell gives it a thickness of 350 feet. Its outcrop underlies

* *Geology of Kentucky*, vol. iii, p. 387.
† I. C. WHITE, *Geol. Survey of Pa.*, G6, p. 116.
‡ *Geol. of Canada*, 1863, p. 364.

lake Michigan from north to south, skirts the southern margin of the Michigan coal-basin, nearly rejoining its former line in Ontario county, on the east, while to the west it runs in a narrow line broken by the northern edge of the Illinois coal-field and is ultimately lost under the later formations in the northwest.

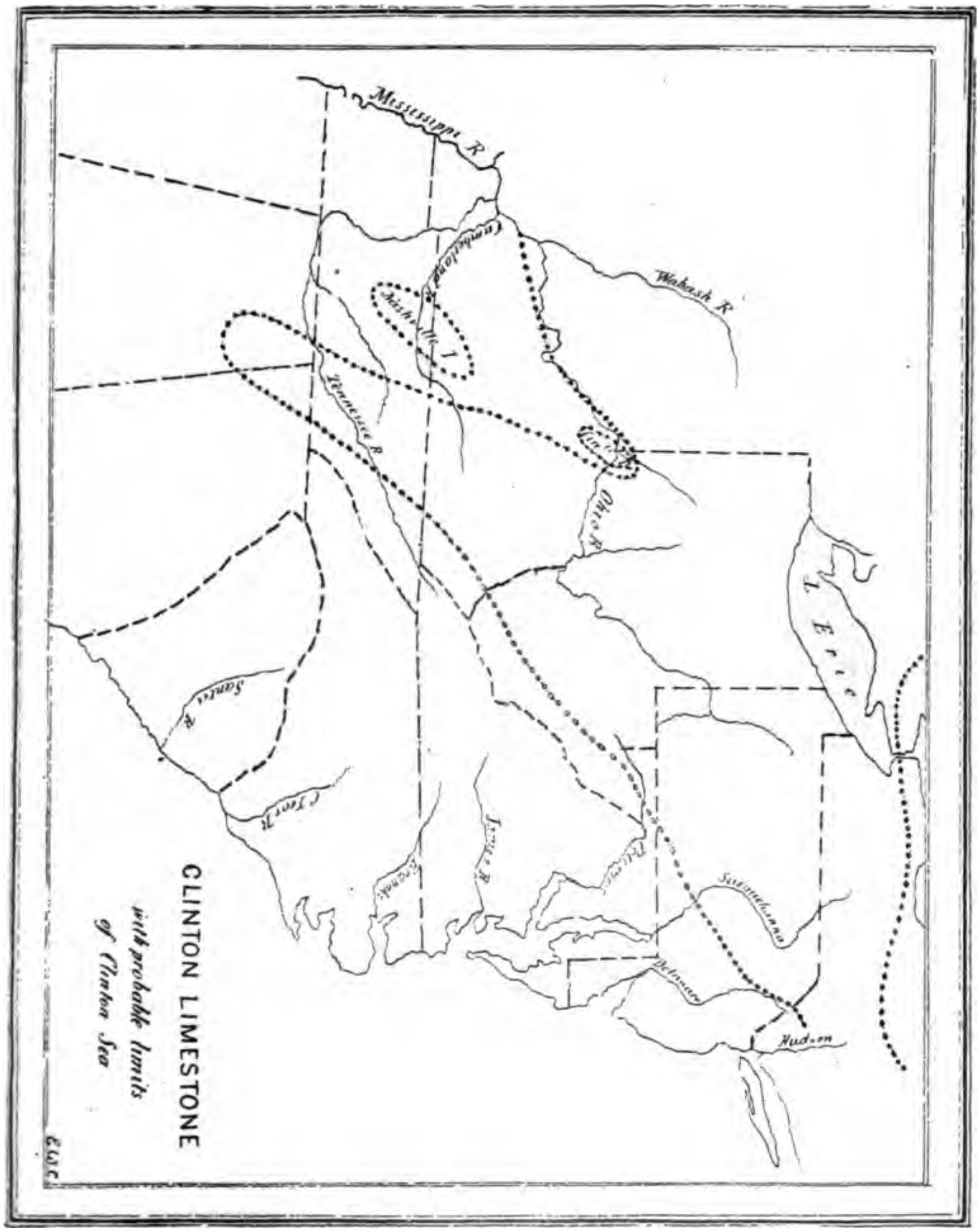
Another branch line of outcrop runs southward through Indiana along the west slope of the Cincinnati arch, and crossing the Ohio river at the Falls, into Kentucky, reaches nearly the middle of that state, where it comes to an end.*

Northeastward from New York the Corniferous limestone may be traced intermittently through Vermont, into Canada, indicating an undefined extension in that direction, while isolated outcrops in the southwest, as in Missouri, prove its continuance at least so far underground. Westward, however, its special characters are lost and it becomes merged in the mass of limestone of which, in that region, the Devonian system altogether consists.

The Great Southern Uplift.—Upon the maps I have attempted, perhaps rashly, to outline the great features of southern Appalachia according to the best data within reach, with the purpose of showing the continuity (not altogether uniform) of the series of movements which were there taking place and which resulted in important changes in the positions and relations of the land and water areas. The maps will further show that this series was inaugurated early in the Silurian era, through which it continued interruptedly, reaching its maximum during the succeeding era.

It should be borne in mind that, at the close of the Ordovician era, no land existed from the mainland in the east far away to the westward, and that disturbances then ensuing raised the Cincinnati arch and produced the islands of Cincinnati and Nashville, at the same time so elevating the eastern land in some places as to provide a source for the materials of the Medina sandstone. Granting that this was the whole extent of the movement, it is obvious that the Appalachian sea underwent thereby a considerable change and that its eastern portion was separated from the main ocean and converted into a wide channel running from the northeast to the southwest

* *Geol. Survey of Kentucky*, vol. iii, p. 394.


CLINTON LIMESTONE
with probable limits
of Clinton Sea
Mississippi R
Wabash R
Tennessee R
Ohio R
L. Erie
Susquehanna
Delaware
Hudson
Santee R
C. Fear R

and occupying the area now composing eastern Ohio, Kentucky, Tennessee, western Pennsylvania and Virginia, with the whole state of West Virginia, besides some adjoining lands. This channel was considerably wider than it would now appear on the map on account of the great folding and compression which the region has since undergone. The western barrier of this channel may have been formed by the two islands, but it is probable that during a part of the era, at least, they were connected, forming a continuous breakwater between the Appalachian channel and the open sea to the westward. There can be no doubt that the southern portion of Appalachia also felt the movement and that a large area was elevated and perhaps remained so during the Silurian era. It is even possible that the southern end of the channel was closed early in the Silurian days. Proof of such elevation is not difficult. Ordovician limestones now overspread the whole of Kentucky and Tennessee and extend into Georgia and Alabama to limits not yet fully known. Erosion and compression have contracted the areas that they originally covered. Consequently the Ordovician sea was at least equally widely spread. But with the beginning of the Silurian era this state of things had passed away. If we allow the Cumberland sandstone described by Shaler in Kentucky to represent the Medina, it alone is an indication of a shore-line at no great distance. But beyond this the comparatively narrow areas covered by the Silurian strata in the southern states give abundant and indisputable evidence in the same direction. The Appalachian sea, already narrowed by the two aforesaid islands which shut off the Appalachian channel, was still farther contracted at its southern end. Safford, writing on the subject says:*—

* "The minor formations composing the Upper Silurian have always occupied areas more or less local, never having been continuous and state-wide, as we have reason to think that the great limestones already described once were.

In some parts of the state, in horizons on which we should naturally look for these rocks and where underlying and overlying formations are present, not a bed is found to represent the group. In the belt of country skirting the western base of the Cumberland table-land this is notably the case, and in every ravine deep enough the outcropping rocks show it to be so. Along the eastern escarpment of the central basin

* *Geology of Tennessee*, p. 291.

from the Kentucky nearly to the Alabama line, the Black shale (Devonian) rests on the Nashville formation without any intervening rock.

On the western escarpment this is also the case at a few points, but generally a Niagara bed has appeared to separate the two, bearing above it here and there a trace of the Lower Helderberg. The Niagara and Lower Helderberg strata are *unconformable* on the Nashville and never covered the dome of the basin."

From this quotation, it is evident that within the limits of the present Tennessee, the Cincinnati-Nashville island in the Clinton and the Niagara periods formed an almost or altogether complete barrier between the open ocean and the Appalachian channel. A narrow passage may at times or even permanently have existed between them, but the Clinton strata are confined to the eastern part of Kentucky, where they are concealed, and to east Tennessee, where they are readily recognized by the conspicuous dyestone ore. Passing the state-line into Alabama they continue along the eastern margin of the coal-fields of that state until they sink and are lost beneath the Cretaceous and later deposits of the gulf shore.

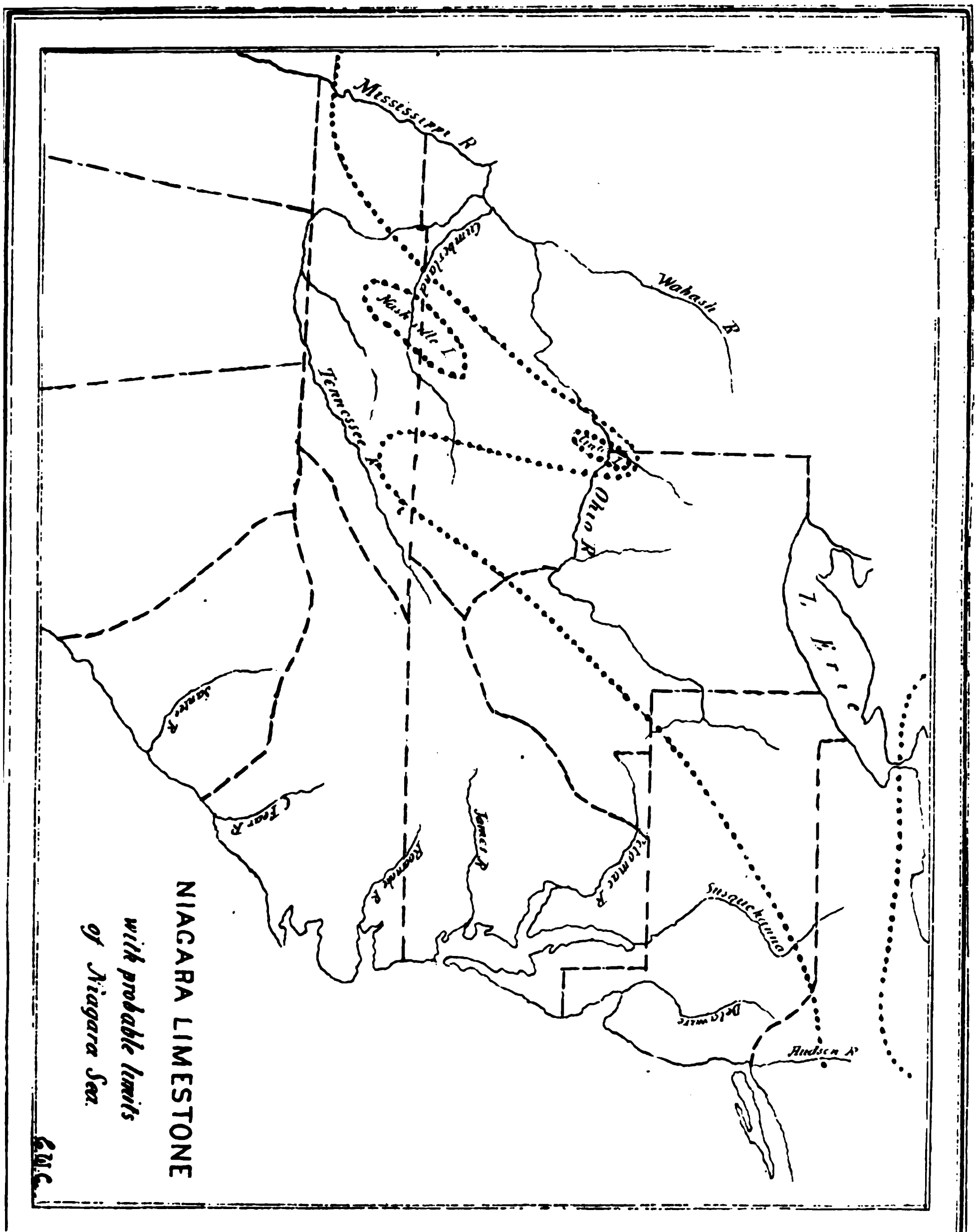
In consequence of this indefiniteness of the outline of the Clinton group at its southern end, it is impossible to determine the boundary of the Appalachian channel in that direction. But in the next period the evidence becomes more satisfactory. The Niagara limestone of New York, which is missing in central Pennsylvania, and is concealed or thin in Kentucky, reappears in the Clinch mountain series of east Tennessee, but extends only a short distance to the south under the name of the Meniscus limestone. On the west, however, of the Nashville island it appears in full force. Regarding the former state, Shaler says:*—

"The next level brings in the beds which apparently answer to the Niagara group, as far as can be determined from the few fossils which they contain. This deposit is seen at points from the Ohio river southwardly to the Tennessee border. The section increases in depth to the southward."

And Safford, in the work already quoted (p. 311) says of it:—

"The Meniscus limestone is eminently the formation of the western valley. In east Tennessee the formation is represented by the Sneedville limestone in the Powell's Mountain group and lying next above the Dyestone shales. Outside the region of the Powell's Mountain group the formation is generally wanting in east Tennessee. It is not

* *Geology of Kentucky*, vol. iii, p. 164.



NIAGARA LIMESTONE
with probable limits
of Niagara Sea.

until we reach the western slopes of the central basin that we meet with it again."

It thus appears, whatever may have been the condition of the southern end of the Appalachian channel during the deposition of the Clinton strata, there can be little doubt that in the Niagara period it had been closed by the uplift occurring in that region, and had been converted into a deep embayment which may be called the Appalachian gulf.

Another line of evidence must not be neglected in following up this argument. It is that in thus tracing the Clinton and Niagara strata away from their typical region both rapidly change their character.

As far as they are found in Ohio, both retain their calcareous nature and are pure limestones, the older calcareous and the younger dolomitic. But neither of them long holds this typical composition after passing on to the southward. In the quotation from Shaler just given he said that the Niagara section increases in depth as we pass to the southward. But he adds (*loc. cit.*): "As we go southward the cherty structure is greatly diminished." "In east Tennessee the beds are very much thicker than in central Kentucky and contain a large amount of coarse sediment principally thin-bedded sandstone and at the top a true conglomerate." Again (p. 394) he adds: "The Niagara limestone is only distinctly marked in certain parts of the state and is generally quite thin."

The obvious deduction from the above quotation confirms the conclusion at which we arrived from the consideration of the outcrop of the same strata, that the shore-line was not far distant to the southward and that, whatever may have been the condition of the area during the Clinton period, it had become before the Niagara had far advanced, a closed gulf, the only connection of which with the open ocean to the westward, was around the northern end of what had become the Cincinnati promontory, or headland, in northern Ohio and Indiana.

The evidence that can be deduced from the Lower Helderberg group as it is developed in the region of southern Appalachia strongly confirms the reality and the persistence of the series of changes which have been outlined above, the closure of the Appalachian channel and its subsequent contraction of the continuance of the great southern uplift. Begun between Ordovician and Silurian days, to it is probably due

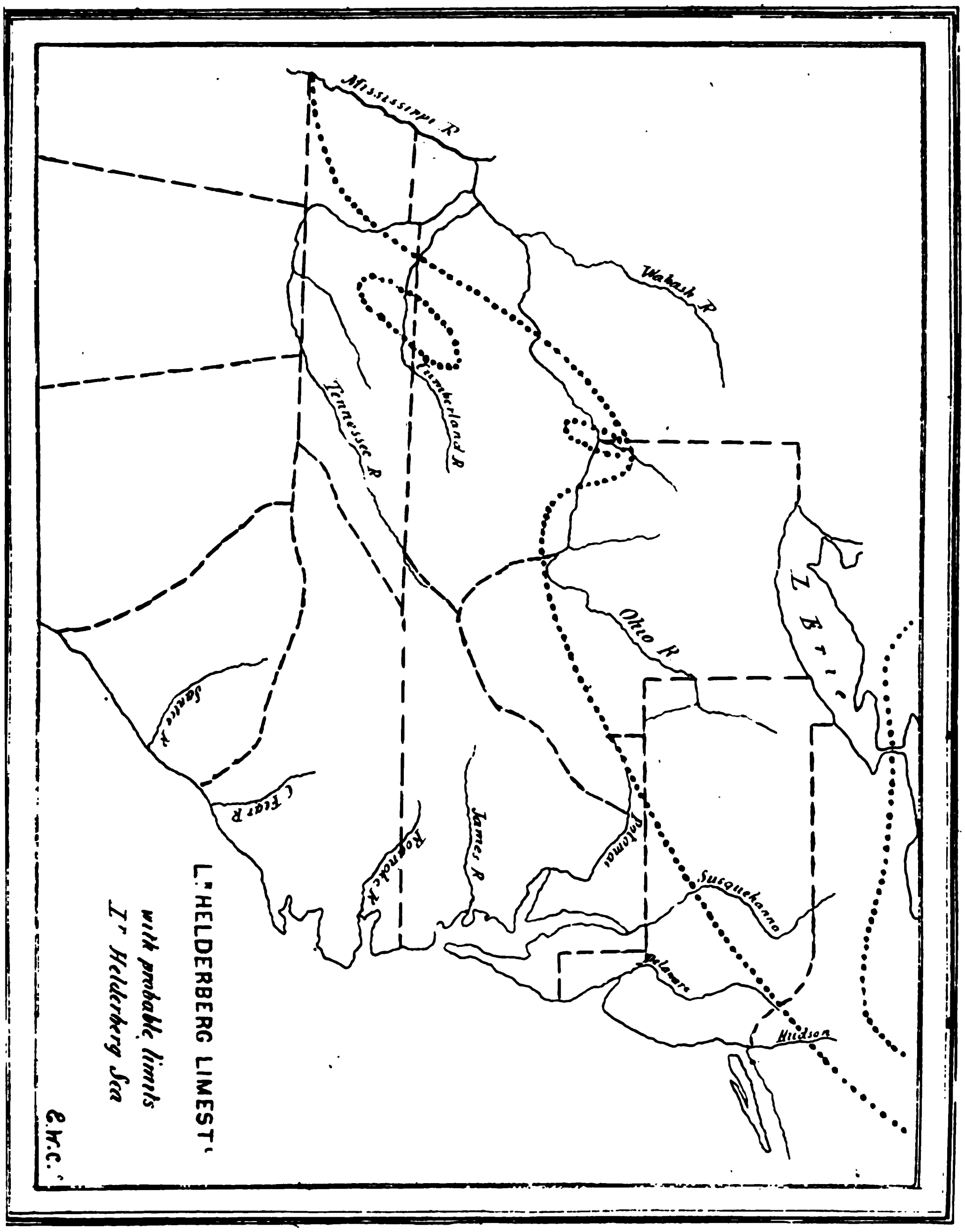
whatever break can be found in the area, either stratigraphical or palæontological. Quoting from Safford:*—

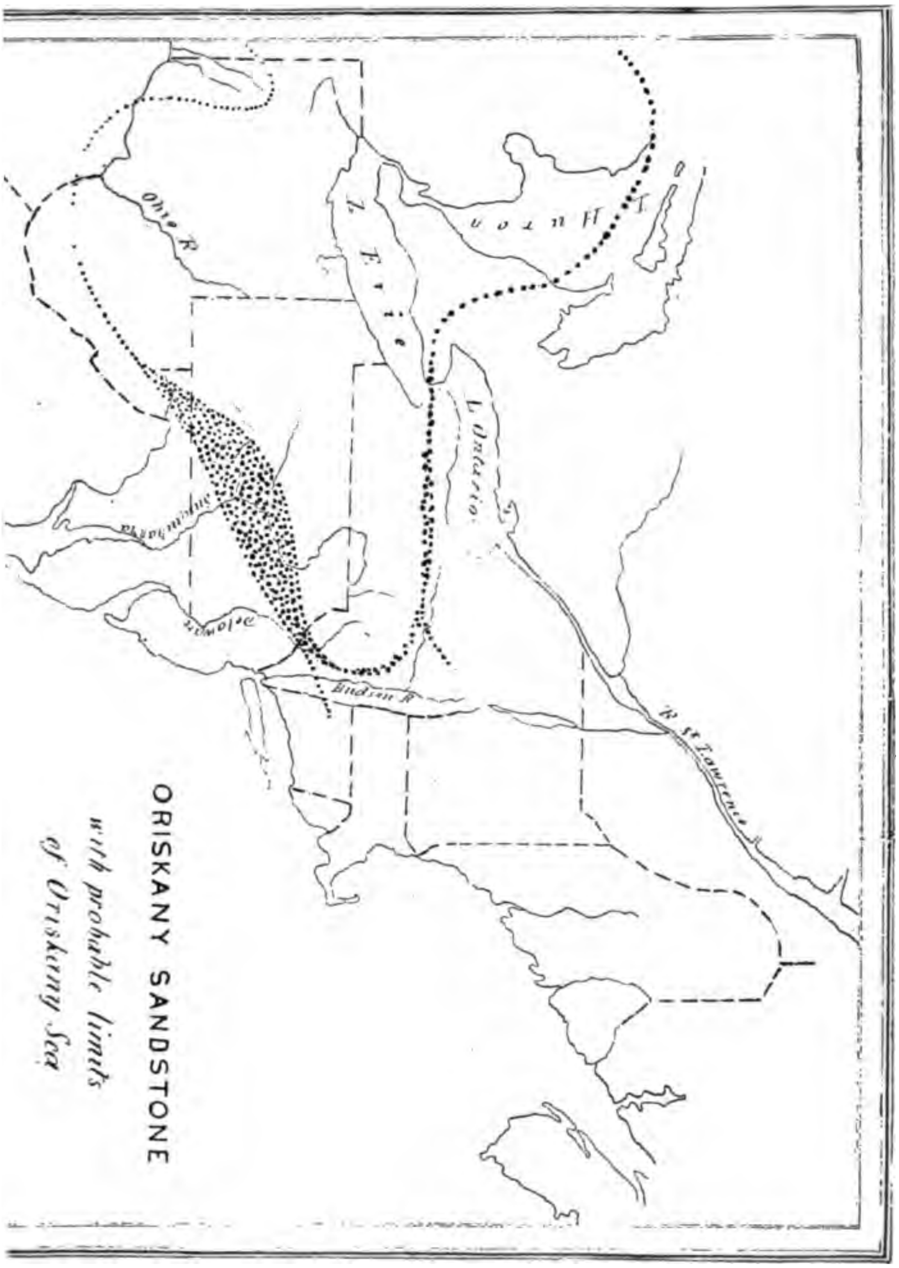
"The Lower Helderberg formation does not appear in east Tennessee. The portion of the state to which it appertains is the western valley and a narrow strip of country adjoining it on the east. The areas and point referred to lie in a narrow strip of the country running across the state and contiguous to the Tennessee river on its west side, in which the strata of all the older formations from the Nashville (Hudson) to the Siliceous (Carboniferous) are suddenly beveled off. It will be safe to place the maximum thickness of the Lower Helderberg at 100 feet. Passing eastward it grows thinner and becomes more or less fragmentary, until it disappears for the most part before reaching the central basin."

These facts show that the Lower Helderberg limestone does not extend so far to the southward in the gulf of Appalachia as does the Niagara. But at what stage in its southern range it runs out, the data accessible do not allow us to determine. It is covered up in Ohio, as already explained, by the overlap of the Black shale in Highland and Adams counties and does not reappear in Kentucky, so that the only means of detecting its presence is by examining the records of deep borings. These show that it passes out of Ohio with its full thickness of at least 500 feet, at Ironton,† from which point it must rapidly thin out in crossing Kentucky, or it would certainly reappear with the Niagara or Meniscus limestone in the Clinch mountain folds.

The legitimate inference is that the Appalachian channel was so far contracted in the Lower Helderberg that it failed to reach the south line of Kentucky, and in the Corniferous period it fell short of what is now the south line of Ohio. Allowance must doubtless be made here for the loss by erosion during the time of elevation above the sea level. But knowledge does not qualify us to do it justly. How far the original limits of the formations involved have been contracted by this means it is impossible to say. The edges of marine strata are and must be eroded during a time of elevation because they are exposed while yet soft to the degrading agents, while the central portions of the same are usually thicker and have longer time to become consolidated before they emerge. But in the present case careful examination leads to the belief that

* *Geology of Tennessee*, p. 322.
† *Geology of Ohio*, vol. vi, p. 304.


Mississippi R
Wabash R
Cumberland R
Tennessee R
Ohio R
L. Erie
Santee R
C. Fear R
Roanoke R
James R
Potomac
Susquehanna
Delaware
Hudson
L. HELDERBERG LIMEST.
with probable limits
of Helderberg Sea
E.W.C.


ORISKANY SANDSTONE
with probable limits
of Oriskany Sea
Ohio R
L. Erie
L. Huron
L. Ontario
Susquehanna
Delaware
Hudson R
R. St Lawrence

the main feature of the above given reconstruction will not be substantially altered by any allowance due to this cause. It is clear for the most part that the geographical development of the gulf of Appalachia and the progress of the southern uplift to which its beginning and its subsequent reduction are both due, followed this general course.

The Appalachian Gulf.—From a consideration of the accompanying maps, on which the history of the development of the gulf of Appalachia has been recorded, it will be seen that with the gradual advance of the southern uplift there occurred episodes of cessation and even of retrogression.* The Clinton of the Silurian, covering but a small area in New York, is thickened in middle Pennsylvania to 1500 feet. Running southward, as already described, its outcrop returns to the north and rounding the end of the Cincinnati promontory bends south and skirts its western slope in Indiana, trending so far to the west that at the falls of the Ohio the group is represented by but twenty feet of sandy material. From this point it is seen no more on the surface within our area.

The Niagara covers an even shorter outcrop in New York and is missing over all middle Pennsylvania. It reappears in Kentucky and Tennessee, where its outcrop returns north and follows that of the Clinton around the Cincinnati promontory, overlapping the latter in Kentucky and Tennessee, thus probably indicating a local subsidence. Beyond this its characters are lost.

The Salina is not shown on the maps as its outcrop is not pertinent to the subject, though in middle Pennsylvania it is 1500 feet in thickness and of equal mass in New York, indicating a great local subsidence in the region.

The Lower Helderberg, overlapping the Niagara in New York, enters Pennsylvania, where it overlies the Salina in the mid state counties and finally sinks to reappear in southern Ohio on the other side of the Appalachian coal fields. It skirts the northern end of the Cincinnati promontory, is apparently lacking at the falls, but again comes up in west Tennessee, with no outcrop in Kentucky, though it probably underlies the western part of the state more or less extensively.

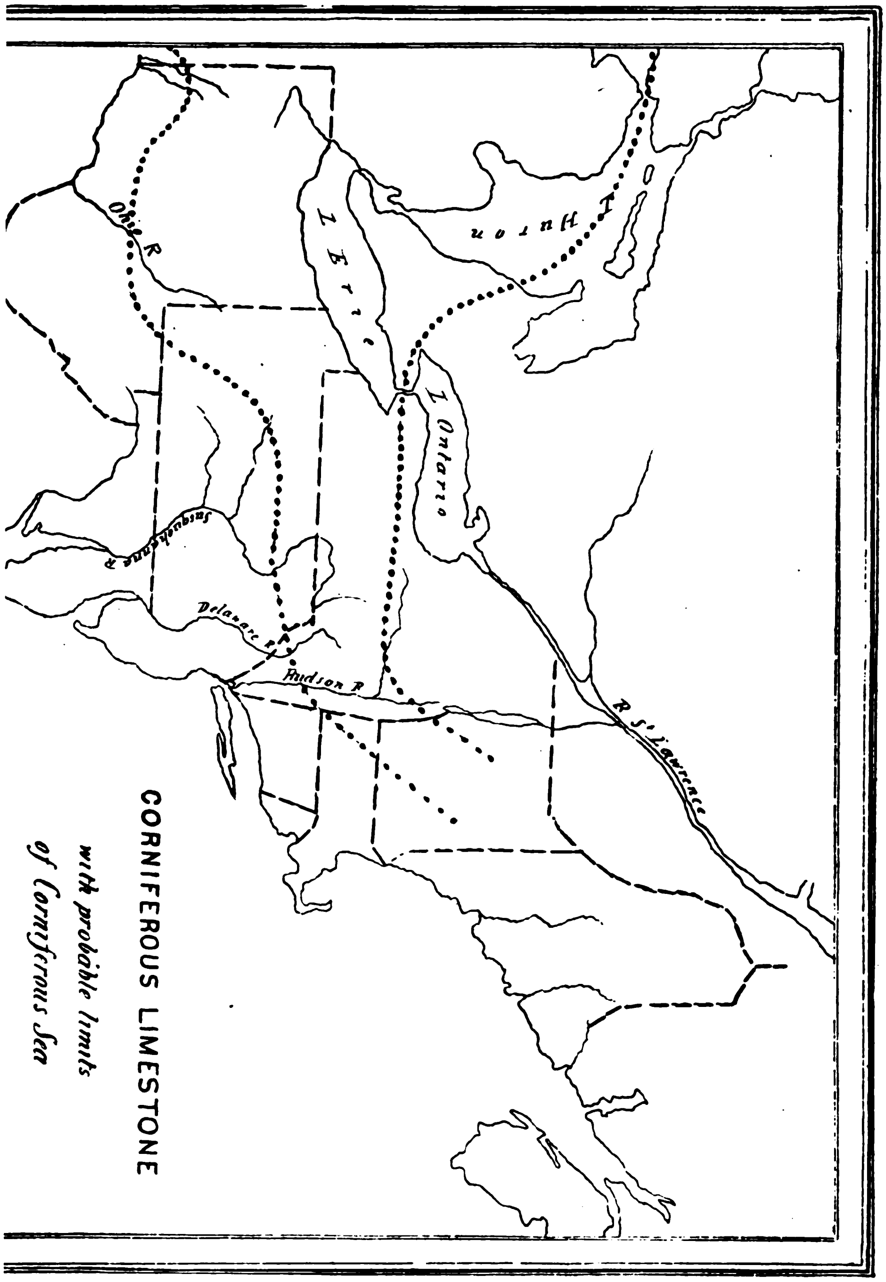
* The islands of Cincinnati and Nashville are marked on the maps for convenience of reference, and not to indicate that all through the time involved they were actually insular.

The geography of the Corniferous period is similar. Its great limestone slightly overlaps the edge of the Niagara in New York, is missing in middle Pennsylvania and only crops out again in Pickaway county, Ohio, after a disappearance of 500 miles; indicating a considerable contraction of the waters beyond their already narrow limits. At this time the whole southern bight had disappeared and the great Appalachian gulf of Alabama, Tennessee, Kentucky, West Virginia and Maryland, with other adjoining and smaller areas had shrunk within dimensions comparatively very restricted.

The Corniferous Sea.—The annexed map may serve to bring out some points more distinctly than could verbal description, thereby rendering criticism more definite and useful.

There is no room for doubt that the greater part of Ohio and of northwestern Pennsylvania, with central New York, the Ontarian and Michigan peninsulas, lakes Erie and Michigan, formed part of the Corniferous sea. Possibly the western side of the last mentioned lake must be excepted, but this is not certain. Illinois and western Indiana, with a small part of Kentucky, the Mississippi basin and large areas outside of it especially to the northward as far as the Arctic region, were also included.

The wide channel running away to the northeastward must be considered as represented rather than mapped, inasmuch as the whole region has suffered so severe a crumpling and erosion that restoration of the original outline is rendered exceedingly difficult. Of the existence of such a channel in earlier days there can be no doubt. A small outlier of Lower Helderberg strata, in place, occurs on St. Helen's isle, close to Montreal, and numerous other exposures carrying the characteristic Devonian fossils can be seen through New England and New Brunswick to Nova Scotia. It is impossible to read the lists of identical species given by Hall and Lyell without admitting that in the Silurian era there must have been a communication with the European area, and it is not easy to see how this can have been the case unless it was along the line of the wide channel indicated on our map. The lessened number of Corniferous species common to Europe and America signifies that the connection between the two areas, though still actual, was reduced or interrupted. The occurrence of several species in


CORNIFEROUS LIMESTONE
with probable limits
of Corniferous Sea
L. Huron
L. Erie
L. Ontario
Ohio R
Susquehanna R
Delaware R
Hudson R
R St Lawrence

common, such as *Cyathophyllum caespitosum* and *Pleurodictyon problematicum,* is satisfactory evidence that, though communication was less free, it was not altogether broken up. When we find well known Appalachian corals such as *Zaphrentis gigantea* and other fossils, as *Spirifera gregaria,* in the Gaspé region, it is equally clear that there was continuous sea between these areas.

In the Corniferous period then an open sea extended from an unknown shore in the far west across the Mississippi valley to an eastern Atlantic margin approximately laid down on our map. Its southern limit in the western portion cannot be easily marked. A long and wide channel ran to the northeast, along a great part of which Corniferous traces have been effaced, but where enough still remains to indicate the past existence of wider deposits. In the far northeast however the beds ceased to be calcareous to the same extent and they betray somewhat more signs of a shore.

Indirect inference enables us to sharpen up this picture and fill in a few more details. Over almost all this immense area the Corniferous limestone maintains a very uniform thickness and composition. Except in a few spots, it seldom exceeds one hundred feet and consists of a very pure limestone mingled in most of its exposures with a greater or less quantity of chert. It is therefore safe to infer that during its deposition no important change of level occurred in the sea- bottom and that no great upheaval elevated the bordering lands of Appalachia. However long the period may have been it was a time of repose in Ohio and the adjoining states. Century after century and millennium after millennium the calcareous sediment sank and slowly built up the massive limestone beds, entombing within it myriads of relics of [illegible] life.

Not only were there no violent [illegible] volcanic
eruptions to break the Cornifer[illegible]
but no secular and gentl[illegible]
characterized the [illegible]
the period be[illegible]
more, the C[illegible]
stained wi[illegible]
belief that [illegible]
Equally sa[illegible]

for the most part the Corniferous limestone is composed, took place at the same rate as now, taking the average thickness of the stratum at one hundred feet, the length of the Corniferous period becomes 20,000 years (Dana), or only 5000 years (LeConte). A duration of between 10,000 and 20,000 years may not be far from the truth.

During all this time there is no indication of even local disturbance on the shores of the Corniferous sea. Except in a very few places the purity of the limestones continues to the outcrop and it may be legitimately inferred that the period was one of rest on land not less than at sea. The southern uplift had apparently ceased; the slight eastern movements which had produced the Oriskany sandstone had subsided; no changes are recorded in the north, and the Carboniferous continent and whatever other dry areas may have existed cannot have presented any very strong relief. They had been eroded during the long preceding ages of the Medina, Clinton, Niagara and Lower Helderberg periods, so that they were approaching a base-level from which little wash was carried down by the sluggish streams that drained their gentle slopes. The material brought into the sea was chiefly in solution and was separated by living organisms for deposit as limestone.

End of Corniferous Period.—No upper limit has been assigned to the Corniferous group. Full consideration of this problem cannot well be undertaken until after the next period has been discussed. However, what has already been said must not be referred to the whole mass of strata which have usually been classed under the name Corniferous in Ohio geology, but only to that part lying below the Bone-bed and to the Bone-bed itself. Where this last exists the physical break is sufficiently conspicuous to afford a good and practical base in the field. Even where it is absent the difference between the lower solid buff limestone and the thinner blue upper beds can be readily detected. It is true that this view is opposed to that which was maintained by Newberry in the Geology of Ohio, and which has been adopted by most subsequent writers. But the evidence in its favor has so increased since the date of the above mentioned volume that at least a reconsideration of the question is justified. This will be done in the succeeding pages. At this time the great calcareous floor of the Appalachian gulf

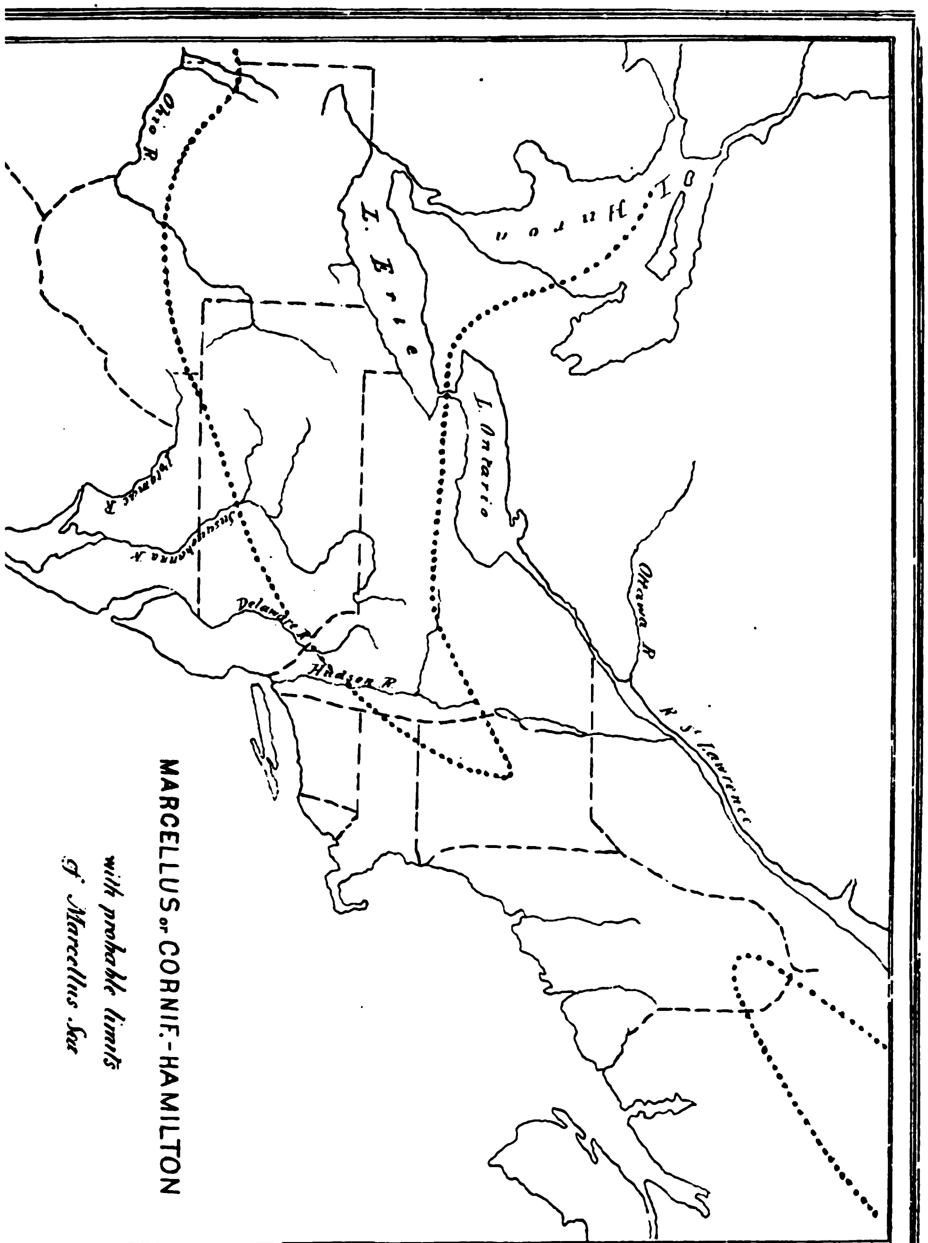
had been laid down and on it began the building of the massive Appalachian strata which it carries and of which Devonia in this region for the most part consists.

B. THE CORNIFEROUS-HAMILTON PERIOD.

A change now came over the scene. The long Corniferous peace was broken and its monotonous limestone formation interrupted. The calcareous deposit which had been in process for millenniums gave way to mechanical sediments and over the whole Appalachian area the sea-bottom and its fauna underwent a radical, but not, save perhaps locally, a catastrophic revolution. The apparently severe and rapid, perhaps orogenic, upheaval to which the formation of the Medina sandstone was due gave place to a long continued but gentle elevation during the whole Silurian era, enduring in the southern Appalachian area even into the Devonian.

Extra-Limital Immigration.—The typical Corniferous in New York was succeeded by a heavy bed of black shale called the Marcellus, and this was again overlain by the Hamilton proper, consisting in different places of limestone, shale and sandstone. The Marcellus in New York seldom exceeds fifty feet in thickness, but in Pennsylvania it rises to three hundred feet. The Hamilton in eastern New York is one thousand feet thick but rapidly thins away to the westward. To the southward, however, it thickens until, in Pennsylvania, it attains fifteen hundred feet and includes a bed of coarse sandstone eight hundred feet thick.

Not only is there a sharp difference between the Corniferous and the Hamilton in the nature of their component sediments but the change is equally marked in their fossils. The new environment did not suit the organisms and they were compelled to migrate, to modify themselves to the changed conditions or to die. Palæontological evidence indicates that a sudden and great, but not complete, break occurs on this horizon. A fauna, in large part new, came upon the scene, doubtless migrating into the area from extra-limital regions, but a certain proportion of the previous inhabitants survived the change, adapting themselves to the circumstances. These amply prove that no catastrophe of wide extent marked the passage from the Corniferous to the Hamilton-Marcellus per-



MARCELLUS or CORNIF.-HAMILTON
with probable limits
of Marcellus Sea

The bed of shale at Prout's Station presents no difficulty, as it lies just on the horizon where the Hamilton would be expected. But the occurrence of *Spirifera mucronata* (*pennata*) in the limestone, as Dr. Newberry admits, although nearly at its top, is a presentation of Hamilton affinity that cannot be overlooked. I make no reference here to professor Winchell's Olentangy shale, because it has no bearing upon the question, but has been brought into the discussion by a confusion on the part of some of the writers on the subject.

An important advance was made in the study of the Lower Devonian rocks of Ohio when, in 1878, a Marcellus horizon was recognized near Columbus by professor Whitfield. His paper on the subject appeared in 1882 in the form of advance sheets of the seventh volume of the "Geology of Ohio."

The following section of the strata in question is given by professor Orton:—

No. 4. Fifteen feet of bluish, somewhat marly shale, the Olentangy shales of N. H. Winchell. This is followed above by the Huron shales, the supposed equivalents of the Genessee shales and Portage shales of New York.

No. 3. Thirty feet of thin-bedded shaly limestone, the Delaware beds of Prof. Orton; the upper part of this is supposed to represent the beds of similar character at Delaware, O., which contain the large fish remains.

No. 2. A thin layer of limestone, four to six inches thick, densely filled with teeth, plates and bones of fishes, locally known as the Bone-bed.

No. 1. A heavy bedded limestone about thirty feet thick, representing the Columbus quarries, including the coral beds and those containing the large cephalopods.

The shale mentioned above (No. 3) with its characteristic fossils, I have no hesitation in pronouncing the equivalent of the Marcellus shale of New York. It lies only a few feet above the Bone-bed. Admitting this, the rocks above this limit should represent the Hamilton group of New York.

But, on a close examination of the fossils, professor Whitfield was unable to draw any very clear line of separation, even at the Bone-bed, the number of species yet known not to pass below it being, he says, very few, while numerous species abounding in the Corniferous of New York are found both above and below it.

Full consideration of all the statements referred to leads to the conclusion that the planes of division between these

groups—the Corniferous and Hamilton—are less sharp in Ohio than in New York, where the transition from the pure limestones of the Corniferous to the black shales of the Hamilton is comparatively abrupt. The corresponding palæontological break is there, as might be expected, much more strongly marked than it is in Ohio, and on this fact professor Hall was enabled to base his definition of the two groups. Moreover, the fauna of the Corniferous in New York is rich, while that of the Marcellus is exceedingly poor and the species are in general of small size. Even there, however, not a few species pass up across the plane of separation, so that the characteristic number of each fauna is much less than the total.

Collecting the data, as we now possess them, from Ohio, we may compile the following section:

Shale at Prout's Station............	Hamilton
Blue limestone, thin bedded.........	Corniferous-Hamilton
Dublin blue shale..................	Marcellus
Bone-bed..............................	Corniferous
Gray and buff limestones...........	Corniferous

The period was, in Ohio, evidently one of transition. Being far distant from the eastern shore of the Appalachian gulf and the influx of eastern muddy waters, Corniferous conditions continued long after they had ceased to the eastward. The Marcellus fauna discovered by professor Whitfield marks the earliest of mechanical sediment, or at least the earliest of invasions of the area by members of the oldest Hamilton fauna. The purity of the Corniferous water was then for the first time sullied by the fine wash from the land, and with this change the mud-loving species were enabled to press in and to supplant those which had so long flourished in the pure, clear sea of the western gulf. *Leiorhynchus* and its comrades migrated westward and colonized the area to an extent at present unknown. But the slow rate of migration attained by similar forms compels us to regard this thin layer of shale as the memorial of no short period of time.

The flood that swept the mud so far out to sea at length subsided and the purity of the waters was restored. Countermigration ensued and the Leiorhynchus fauna succumbed to the survivors and to the descendents of the displaced Corniferous fauna, which had been temporarily driven to seek an asylum in the west. It was long before they again gave way, but when

they next yielded, so far at least as we yet know, they returned no more.

But the changes were far from complete. Not all the Corniferous fauna were killed by the changed environment. Some adapted themselves to it and lived. Nor did the whole immigrant fauna die off when the water cleared. Some of its members proved capable of holding their own and the mingled species lived on together.

The Hamilton fauna, at least the Marcellus division of it, must have been settled in New York and Pennsylvania long before it appeared in Ohio. Where it originated is a matter for separate inquiry. There is no room for doubt that the migration was in a westward direction. Consequently the stratum of shale in Ohio on the Scioto cannot correspond in age with the base of the Marcellus in New York, but it must be correlated with some higher horizon. As the Marcellus ranges in that region between fifty and three hundred feet in thickness considerable latitude can be allowed. The facts warrant the statement that Corniferous conditions prevailed in Ohio throughout the whole of the Hamilton period in New York, with a few temporary and local interruptions marked by the beds of shale above described.

The Hamilton Sea.—The only representative of the typical Hamilton of the east is, as we have seen, the thin marly band of shale cropping out at Prout's Station, in Erie county, from which Dr. Newberry has reported the following fossils*:

Spirifera mucronata, Cyrtina Hamiltonensis, Strophodonta demissa, Athyris spiriferoides, Heliophyllum halli, Phacops bufo, Ancyrocrinus (probably *bulbosus*).

It is needless to discuss the evidence of so characteristic a list of fossils as the above, but they have, so far as I am aware, been met with nowhere else in the limits of the state. The thin band of shale in which they occur is due in many other places, in fact wherever the junction of the upper limestone with the overlying shale is visible. But its non-discovery by no means proves its absence. So thin and soft a stratum might easily be overlooked even in outcrop or might be entirely obscured or removed by weathering. And in the process of drilling by no chance could such a bed be distinguished in the wilderness of

* *Geology of Ohio*, vol. ii, p. 190.

many-colored shales through which the auger descends in search of gas or oil or salt. It is consequently impossible to show its extent over the state or to map the exact minimum area of the Hamilton sea in Ohio. By indirect evidence, however, it is possible to indicate the larger details of the geography of the period in the gulf of Appalachia with considerable accuracy, and thus to see its connection with that of the preceding periods.

The general outline of the western part of the Appalachian gulf differed from that represented in the map of the preceding Corniferous-Hamilton period. The wide opening around the north end of the promontory of Cincinnati still maintained communication with the open western ocean and a shore line extended along the western side of the arch to the site of the present falls of the Ohio, where, as above shown, the upper beds have a strong Hamilton affinity. Turning to the eastword, the coast-line swept inward, for the most part coinciding or nearly coinciding with that of the preceding period. The absence or non-recognition of the true Hamilton in the outcrops of central and southern Ohio may, if not resulting from defective evidence, indicate that the land there was somewhat more extensive than previously—a consequence, probably, of the continued elevation of the Cincinnati arch. Eastward, however, the reverse of this condition prevailed and throughout middle and eastern Pennsylvania the Hamilton waters overflowed the former shore lines and converted into sea what had before been dry land. In that region, where, as already pointed out, the Corniferous limestone is largely missing, the thick beds of the Hamilton rest on the Oriskany or on the Lower Helderberg directly. There, also, the formation attains its maximum thickness of 1500 feet. What additional area to the southeast should be added to allow for the crumpling, folding and erosion that have since then taken place it is not possible to say, but beyond question the Hamilton shore-line lay many miles beyond the extreme outcrop of the Hamilton strata.

Sweeping northward through New Jersey and New York to the Hudson river near Albany the outcrop of the Hamilton turns thence to the west and passes below lake Erie at Buffalo. Reappearing on the north shore it runs northward and divides, one branch passing under lake Huron, across Michigan and

then under the lake and around the southern edge of the Michigan coal-field returning to its starting point near Sarnia. The smaller branch which emerges from below lake Erie, at Sandusky, and borders the Cincinnati axis, has been already sufficiently described in writing of its outcrops at Prout's Station.

The line of outcrop which doubtfully appears on the western side of the Cincinnati arch has not revealed any distinctive Hamilton features and the long continuation of the same to the northwest almost to the shores of the polar sea merely indicates Devonian conditions continuing unchanged throughout the period, and the existence of a Devonian ocean throughout the whole area, in which no breaks either stratigraphic or palæontologic can be detected.

Changes of Level.—As already stated, the nearly uniform thickness of the Corniferous limestone indicates a stable condition of the sea bottom over its whole area and the absence of any considerable disturbance along its shores. The incursion of mud and sand over part of the same area during the succeeding periods is equally conclusive proof of instability.

From the facts already given we can at least roughly outline the more important changes of level that occurred in the Appalachian area at the close of the Corniferous period and before the setting-in of the Marcellus or Corniferous-Hamilton. There is no ground for predicating any rise or fall within the Ohio area. The outcrop of the upper division of the Corniferous limestone (of the Ohio survey), including the thin shale which alone represents the Marcellus in the state, coincides with the lower buff beds around the line of their joint outcrop in Ohio, Indiana and Kentucky, so that the shore-line of that group remains unaltered.

But eastward important changes occurred. On the reappearance of the Corniferous-Hamilton as the Marcellus on the other side of the Appalachian coal-field we find its shore far overlapping the edge of the Corniferous limestone, there invisible, and the Black shales lying on the Oriskany sandstone with nothing intervening. We must hence infer that an area approximately equal to that which received the Oriskany sandstone and which was raised so as to be above water—probably only to a slight extent in the Corniferous period, again sank to receive the Marcellus shale. This depression included all middle Penn-

sylvania, parts of Maryland and Virginia, with an unknown extension into the now folded region beyond these limits. Its amount varied but along the most easterly line of outcrop where the strata are seen for the last time, it cannot have been less than several hundred feet— the Marcellus black shale ranging from 250 feet in the middle counties to 800 feet on the Maryland line,* if the whole of the mass of black shale is rightly assigned to it. Consequently the southern bight of the gulf was considerably deepened into the land, regaining somewhat of the dimensions which it had possessed in Silurian days.

At the same time, the fineness of the Marcellus deposit confirms the view already presented that the former elevation of the land had been but slight. But during, or, perhaps, at the beginning of the period now under discussion, the inner portion of the Appalachian gulf subsided to the above extent, forming a deep basin in which were laid down the finer washings of the eastern and southern lands so saturated with organic matter as to become of an almost coaly blackness.

In another direction a somewhat similar hypsographic change is indicated. The long but undefined Laurentian channel to the northeast, whereby communication was probably maintained with the European seas, and which had been apparently somewhat contracted even in Corniferous days, seems to have been now completely closed by an elevation which affected a considerable part of New England and of Canada adjoining it. This led to the erosion which continued into succeeding periods. The movement which had prevailed in the south during the closing ages of the Silurian era was now transferred to the northeast and there it persisted until its effects became as marked and as extensive as those already described.

The middle part of the Laurentian channel probably first felt the elevating force and was raised above the water-level, leaving the two ends as deep gulfs running one to the northeast from the present Hudson valley and the other to southeast from what is now the gulf of St. Lawrence. Continued and extending elevation increased the area of the new land and, by developing rivers, converted the two gulfs into estuaries which were gradually filled with the deposit of the streams. In later times even this has been again removed, and now only traces

* STEVENSON, *Geol. Sur. of Penna.*, T2, p. 82.

THE HANGING VALLEYS OF GEORGETOWN, COLORADO.*

By W. O. Crosby.

PLATES XI-XIII.

Georgetown is situated in the valley of Clear creek, a tributary of the South Platte draining the eastern slope of the Main Range in the latitude of Gray's Peak, in the county of Clear creek, fifty miles by both creek and railroad from Denver, and at an altitude of 8,500 feet. The town lies at the northern foot of Leavenworth mountain (Figure 1) which, continued above timber line in McClellan mountain, divides the main stream from the important tributary known as Leavenworth creek. Below Leavenworth mountain the trend of the valley is northward for about two miles, between the long, straight ridge of Griffith and Saxon mountains on the east and the slightly divided Republican, Democrat, and Columbian mountains on the west, to the foot of Empire pass, where Columbia mountain is connected with Douglas mountain by a low, sharp ridge. At this point a long detrital cone, heading in a prominent gulch on Saxon mountain, obstructs the drainage across the entire breadth of the valley. Below this obstruction the bottom of the valley is narrow, with little or no level land, and the stream falls rapidly as it winds around the base of one detrital cone after another; but above it, to the upper end of Georgetown and the base of Leavenworth, the valley floor is approximately level for a breadth of 1,000 to nearly 2,000 feet, suggesting the silted-up bed of a temporary lake, above which the mountains rise abruptly 3,000 to 4,500 feet. Up stream the north-south course of this part of the valley is continued in the valley of Leavenworth creek, between Independence mountain on the east and Leavenworth mountain on the west, as far as the beautiful morainal lakelets known as Green lake (2½ miles) and Clear lake (3 miles) and beyond; while Clear creek, above Georgetown, swings in a graceful curve to its normal westerly course before reaching Silver Plume (2½ miles) and holds this course to its source in the Snowy Range.

The interest of this paper centers in the relations of these two valleys to that part of the main valley immediately below

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FIG. 1.—PANORAMIC VIEW OF THE GEORGETOWN VALLEY, SHOWING ITS ABRUPT TERMINATION AGAINST THE NORTHERN FACE OF LEAVENWORTH MOUNTAIN, WITH THE HANGING VALLEY OF LEAVENWORTH CREEK ON THE LEFT AND OF CLEAR CREEK ON THE RIGHT.

FIG. 2.—VIEW LOOKING UP THE GORGE OF LEAVENWORTH CREEK.
The sky-line on the right shows, in profile, the original, base-leveled floor of the valley.

FIG. 3.—VIEW FROM HALL'S LEDGE LOOKING UP THE VALLEY OF CLEAR CREEK, WITH THE DEVIL'S GATE GORGE IN THE MIDDLE DISTANCE.
The low ridge of granite in the foreground separates the bed of Clear creek on the right from the relatively low plain on which the main part of Georgetown is built.

Leavenworth mountain and occupied by Georgetown, nearly the entire field of the study being shown in Figure 1. Below the high moraines enclosing Green and Clear lakes, the valley of Leavenworth creek is wide and its gradient low, the stream meandering somewhat across its approximately base-levelled floor. As it approaches Georgetown, however, the creek begins to trench the floor of this mature mountain valley and, falling about 700 feet in the last mile, it escapes abruptly into the still broader Georgetown valley, through the deep V-shaped gorge shown in Figure 2, and less distinctly in Figure 1. The general relations of the two valleys are well expressed in Figure 1, which affords an excellent transverse profile of the upper valley and shows it ending abruptly downward in a steep and almost precipitous slope, and thus clearly holding the relation of a hanging valley to the lower valley.

The main problem, of course, lies in the significance of this break between the two valleys; and three general explanations demand consideration—fluvial erosion, glacial erosion, and displacement.

Obviously the floor of the valley of Leavenworth creek was once continuous with the floor of Clear Creek valley. The first explanation of the existing discordance, or lack of continuity, would mean that Clear creek has, in later times, lowered its bed more rapidly than Leavenworth creek, by virtue, we may suppose, of the advantage which, during the elevation of the range, a main stream would enjoy in experiencing acceleration more promptly than its lateral or right-angled tributaries. This is an important principle, and fully competent, no doubt, to explain many hanging valleys; appearing, for example, to account perfectly for the hanging tributaries of the upper San Joaquin river in California. But the conditions at Georgetown are clearly unfavorable to its application, since the escarpment in which both the valley and gorge of Leavenworth creek terminate is in the lee of Leavenworth mountain with reference to the direct and normal course of Clear creek, and cannot possibly be regarded as due to the erosive action of the latter. The hypothesis of more vigorous glacial erosion in the main valley, appealed to by Davis and others in explanation of some of the hanging valleys of the Alps, and more recently of other districts, is beset by still greater difficulties here; for I have failed

to find below Leavenworth mountain any evidence of glaciation. The mountain slopes are here wholly unglaciated, and all apparent moraines are really detrital cones heading in lateral gulches, forcing the creek against the base of the opposite slope and thus causing it to meander in spite of its rapid fall. But even granting that the glacier of the Clear Creek valley did cross the site of Georgetown, the salient northwestern angle or spur of Leavenworth mountain would prove a still more serious obstruction than before; nor could we appeal with more success to the phenomena of the bergschrund, for surely this basin, a dozen miles from the heads of the valleys in the Snowy Range, was never an amphitheatre of névé; on the contrary, we must think of it as in any case near the lower limit of glaciation and well below the line above which the formation of glacial ice or its firm adhesion to the bounding rocks is possible.

We have next, then, to inquire whether the facts are more favorable to the displacement hypothesis. In this connection some of the vein phenomena of the district are significant. Traversing the lower slope of Griffith mountain, to the north of Leavenworth creek, is the Griffith lode, which may be regarded as virtually continuous to the south and southwest with the lode system of the Alaska, Centennial, Burrell, and Big Indian mines, crossing the mouth of Leavenworth gulch just below the escarpment and traversing the northern face of Leavenworth mountain to and through the prominent notch high up on its northwestern spur. The workings of the Centennial mine with a depth of 600 feet and a length of over 1,500 feet, extend directly across the mouth of Leavenworth gulch and reveal perfectly the character of the fissure at this most critical point. Here, as throughout its course, it is an approximately plane, vertical, and vertically striated wall, characterized at most points by a clay gouge from six inches to a foot or more in thickness, and by more or less extensive sheeting of the granite complex, as well as by frequent oblique breaks, or branch fissures, in which the filling of quartz and ore chiefly occurs. A more ideal fault fissure it would be difficult to imagine; and that the movement has been in part geologically recent is indicated by certain features of the Griffith and neighboring mines to which my attention has been directed by Mr. J. S.

Randall, of Georgetown. For a length of a mile or more along the lower slope of the mountain the country rock is in a shattered condition, so that very little continuously solid rock is found, even at a depth of hundreds of feet, the structure being so open at some points as to permit a free circulation of air through the ground. Undoubtedly the fissure system and the veins antedate the modern escarpment, at least in the main; but that there has been comparatively recent movement along this line is unquestionable; and of this the unlithified selvage, and not uncommon brecciation of the vein contents, with deposition of cryptocrystalline secondary quartz, are evidence.

There is evidence in the vein developments and in the breaks of the northwestern spur of Leavenworth mountain that the fissure system divides in this mountain, a more northerly branch following and defining the northern base of the mountain and thus determining the abrupt and square southern end of the Georgetown valley. A fracture system, which might be regarded as either a southward continuation or a repetition of the main Griffith-Centennial line, traverses the eastern slope of Leavenworth mountain. It is well exposed for study in the extensive workings of the Aliunde mine, and is seen to be characterized by a dike of porphyry, the geological recency of which is indicated by its broad margins of obsidian. The dike probably postdates the ore development, in the main, but the indications of movement subsequently to the formation of the dike are also very plain; and the downthrow is here quite clearly to the east and not to the west, although still on the side towards the valley. The chief topographic indication of this displacement is found in the dislocation of the tributary valley of Argentine creek, which thus holds the relation of a hanging valley to the valley of Leavenworth creek. In this instance the creek has notched its escarpment less deeply and, falling several hundred feet in a small fraction of a mile, develops the water power utilized in the operation of the Aliunde mine. That the displacement at the foot of Leavenworth gulch is not measured in its entirety by the hight of the escarpment, as shown in Figure 1, is proved by the fact that while the Dewey & Wheeler concentrating mill, which is the point of view for Figure 2, stands on bed rock, which was blasted to prepare the foundation, a shaft about 100 feet from the mill, on the north

side of Fourth Street, reached bed rock only at a depth of 125 feet. West of this a second shaft(now filled up) was sunk in 1870, near the corner of Rose and Third Streets in Georgetown, where the surface is approximately fifty feet lower (the first shaft starting on the detrital cone originating in Leavenworth gulch), and not more than 150 feet from the steep base of Leavenworth Mountain, reaching bed rock at a depth of seventy-five feet. Half a mile to the northward, and close against the base of Griffith mountain, near the mouth of the lower tunnel, a shaft reached bed rock at 60 feet; and a short distance north of this, near the present base of the high dump of the main Griffith tunnel, and possibly not over 100 feet from the base of the mountain, a well was sunk in early days to a depth of about 100 feet without reaching bed rock.

In view of these facts, it can hardly be doubted that the part of the valley occupied by Georgetown is a depressed fault block, or graben, and that the valley is due in part to displacement and not wholly to erosion, thus suggesting comparison with Yosemite valley. This view calls for another and complementary fault along the west side of the valley, at the base of Republican mountain, and of its existence we have ample evidence, although in this instance the displacement is not close against the mountain. The confluence of the two creeks is not near the foot of Leavenworth mountain, as would be most normal, but half a mile or more to the northward; and as a specially interesting and puzzling feature in the topography of Georgetown we have the narrow ridge of granite extending north from the northwestern corner, or spur, of Leavenworth, separating Clear creek from the level plain on which the main part of the town is built and terminating abruptly in the bold knob on which formerly stood the brick stack of Hall's reduction works. This knob or ledge is the point of view for Figure 3, which shows the ridge of granite bordered by the bed of Clear creek on the right and connecting upward on the left with the angle of Leavenworth mountain. On the west side of this ridge, which at the lowest points is not more than five feet above the creek, the latter actually or practically flows in the bed rock surface, while on the east side the level gravel floor of the valley is ten to twelve feet, and the bed rock floor eighty-five or ninety feet, below the level of the creek. Obviously the

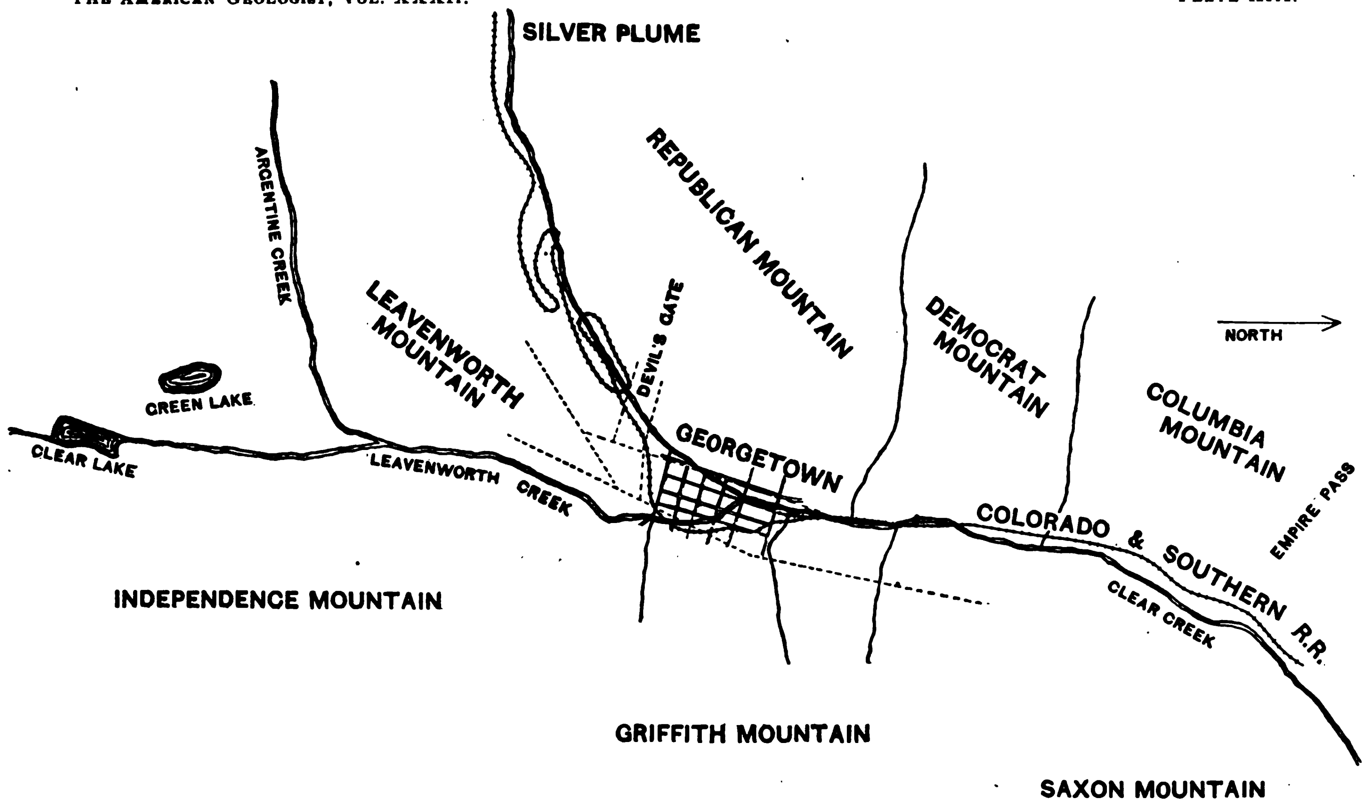

FIG. 4.—MAP OF GEORGETOWN AND VICINITY.

The broken lines show the probable locations of faults defining the Georgetown graben. Scale: One inch = about 4,000 feet.

east side of this ridge is on a fault with the downthrow to the east, running straight up the north face of Leavenworth mountain, intersecting the oblique and east-west faults previously described and giving the northwestern angle of the mountain its salient character. The ridge just described, terminating in Hall's ledge, is clearly only a narrow remnant of the gradually tapering north end of Leavenworth mountain, which, we may or must believe, once separated the two creeks. Accepting this view, the displacement of the bed rock surface is probably not less than 100 feet; and the most anomalous feature is seen in the fact that the creek is left on the upthrow side for one-third of a mile after entering Georgetown basin. Sedimentation in this basin has virtually obliterated the fault as a topographic feature of the valley floor and destroyed the water power to which it gave rise. Were the valley cleared of detritus, the part of the valley of Clear creek above the fault would become a hanging valley in its relation to the Georgetown basin, or graben, or that part of the valley below the fault.

Under existing conditions, however, and in spite of the accumulated detritus below the main fault just described, the floor of this valley is abnormally elevated for a short distance, where it is trenched by the gorge, some seventy-five feet in depth, known as the Devil's Gate (Figure 3). The part of the valley above the Devil's Gate, which may conveniently be designated the Silver Plume valley, is, aside from the morainal deposits which terminate half a mile or more above the Devil's Gate, flat-bottomed and free from a gorge down to the beginning of the Devil's Gate, where the rocky floor is abruptly uplifted at least seventy-five feet. In other words, local movement, or block faulting between two of the fractures crossing the northern face of Leavenworth mountain, has raised a rock dam across the valley here approximately seventy-five feet high and 500 to 800 feet broad up and down the valley. Through this dam the stream has cut its gorge; and the absence immediately above this barrier of stratified deposits or any evidence of a lake is a plain indication that the elevation was gradual, and so slow that the stream kept pace with the movement. The former course of Clear creek across this elevated tract can be traced along the line of the railroad east of the gorge in the waterworn ledges and pot-holes and well-rounded and water-

worn gravel and bowlders identical with those of the modern stream bed, in which pot-holes are also forming. Farther up this valley we have similar and equally clear evidence of geologically recent faulting in the immense semi-detached block of Sherman mountain, rising precipitously from the north side of the valley between the village of Silver Plume and the group of rich mines, in the workings of which the fault fissures have been extensively and clearly developed and repeat the phenomena of the Aliunde Mines on the eastern slope of Leavenworth mountain.

Taking a broader view of these phenomena, it appears improbable that they are peculiar to this district, but rather that they are characteristic of many of the drainage systems of the mountains, especially towards the headwaters and the axis of the range. The idea is inevitably suggested that the elevation of this great mountain mass, the broadest and possibly one of the oldest of the Colorado ranges, has been recently, and may be still in progress; and that while in the past the movement has been chiefly massive, developing the magnificent fault scarp overlooking the plains, it has in later times affected the axis more than the margin of the orographic block, leading to a marked tilting of the Cretaceous peneplain represented by the broad, grassy uplands or shoulders (alps) of the mountains; and in part, at least, the uplift is very locally differential and, in the Georgetown instance, in a way to accentuate the topography.

EDITORIAL COMMENT.

THE QUANTITATIVE CLASSIFICATION OF IGNEOUS ROCKS.

With the introduction of the microscope into petrography it became early evident that existing systems of classification, if such they could be called, would need very decided modifications to meet the new requirements. Indeed, the entire aspect of matters changed so rapidly that, for a time, it seemed that confusion had been confounded, and a consistent and philosophical classification of rocks rendered hopeless. As time went on, however, as knowledge regarding structure, magmatic differentiation, and occurrences, increased, new schemes

were proposed or various modifications suggested of existing schemes, each of which served to illustrate the condition of knowledge at the time or, perhaps, merely the writer's conception of that knowledge. Naturally, all failed, though this not necessarily through fault of those making the attempt, but rather through the fundamental fact that sufficient information was not available—the time had not arrived.

The principal result of the attempts of the past twenty years, as manifested in the literature, consists in the coining of new names, the criteria for which were furnished by each worker independently. It is perhaps still a question if we have arrived at a sufficient knowledge of the essential criteria for a satisfactory classification. Be this as it may, attempts are still being made and the one now before us is sufficiently serious to demand more than a passing notice.

And first, it should be stated that, whatever may be one's personal views on the subject, he can but be impressed with the fact that the Quantitative Classification of Igneous Rocks, as recently issued by the University Press of Chicago, is the work of good authorities. Had American petrologists been called upon to name four individuals who, by training and profession, were best qualified to undertake this task, it is safe to assume that a very large majority of them would have decided without hesitation upon the four whose names are given on the title page.

The work begins with chapters on the views held prior to the nineteenth century and on the development of systems during the nineteenth century, this being followed by a chapter on the beginning and development of the microscopical era. These chapters constitute about one-third of the book and form a very satisfactory historical resumé.

The part relating to the classification now put forward is, however, of primary interest. As here treated, all igneous rocks are classified on a basis of their chemical composition, all rocks having like composition being grouped together. The definition of the chemical composition of a rock is expressed in terms of certain minerals such as are capable of crystallizing from the magma of a given chemical composition, the expression being quantitative. Otherwise expressed, the classification is primarily magmatic. These are fundamental principles

to which few will take exception. In carrying out this plan the principal rock-making minerals are divided into two groups consisting, on the one hand, mainly of the more highly siliceous, alkali- and calci-aluminous ones and, on the other, of the ferro-magnesian ones, the first group being known as *salic* and the second as *femic*. For the purpose of completely classifying a rock by this system, it is, therefore, necessary to know its composition, as determined by chemical analyses, or, if holocrystalline, by optical methods.

Recognizing the fact that certain magmas may crystallize into quite different mineral combinations, according to attendant conditions, the authors have found it necessary to select a certain set of these salic and femic minerals as uniform standards of comparison, the standard mineral composition of the rock being called its *norm,* while its actual mineral composition, which may or may not be different from the norm, is called its *mode.*

Starting with these groups, the rocks are divided into five classes, according as one or the other of the groups of standard minerals constitute the norm or is extremely abundant, whether one or the other is dominant, or whether the two are in about equal proportions. The classes thus formed are divided into *orders,* which are based on the proportion of quartz to feldspar and feldspar to feldspathoids, or that of silicate to non-silicate minerals, accordingly as salic or femic minerals preponderate. Orders are again divided into *rangs,* which are founded on the chemical nature of the bases in the preponderant salic or femic group, and rangs into *grads,* which in their turn are based on the general acidic proportions of the subordinate minerals. Each of these divisions may be further divided, giving rise to sub-orders, sug-rangs, and sub-grads, if occasion demand.

In searching for a nomenclature the authors have adopted one which is necessarily entirely new and it must be confessed, not at all times quite pleasing at first glance. As proposed, this is polynomial and based upon the very sensible plan of conveying an idea of the character of the mass to which any name may be applied. To this end names are given which convey a definite cenception of magmatic and consequent *norm* or standard mineral composition; these are then qualified

by adjective terms, referring to *mode* or actual mineral composition and texture.

The magmatic name adopted consists in each case of a root derived from a geographical name, except for those of classes and sub-classes, and of a suffix, the suffixes themselves being so chosen as to vary in a definite way with the division of the system to which the magmatic name belongs. Thus, for class, order, rang, and grad, the letters n, r, s, and t, in the order given, are used with the vowel *a*, giving in English the termination *ane, are ase, ate.* For subclass, suborder, etc., the vowel is changed to *o*, giving *one, ore, ose, ote.*

In calculating the standard minerals, their amount and kinds, a method has been developed of considering first, the chemical composition of the rocks and from this calculating the standard minerals, and then considering the actual mineral composition, the standard mineral composition being rendered necessary by the fact that all igneous rocks are not holocrystalline.

The work is so concisely written that, to illustrate in detail the methods employed, would practically amount to an entire reprint. A partial attempt may, however, be here made. Thus, it is proposed to divide the igneous rocks into five classes, according to the calculated proportions of the standard mineral groups, which, as already stated, are designated as sal and fem in the formula, the prefix *sal* being the abbreviated form of silica-alumina and *fem* of ferric-magnesian.

The various classes, then, would be expressed by the formulæ given below, written according to the relative abundance of the salic and femic minerals. The class name as given follows the formula. For the purpose of further illustration the reader is here referred to the table on page 52.

Class I: $\frac{\text{sal}}{\text{fem}} > \frac{7}{1}$ persalic.

Class II: $\frac{\text{sal}}{\text{fem}} < \frac{7}{1} > \frac{5}{3}$ dosalic.

Class III: $\frac{\text{sal}}{\text{fem}} < \frac{5}{3} > \frac{3}{5}$ salfemic.

Class IV: $\frac{\text{sal}}{\text{fem}} < \frac{3}{5} > \frac{1}{7}$ dofemic.

Class V: $\frac{\text{sal}}{\text{fem}} < \frac{1}{7}$ perfemic.

Table showing the new nomenclature and terminology as applied to some of the better known igneous rocks.

(Computed by Dr. E. B. Mathews and presented in a paper read before the Geological Society of Washington, March 11, 1903.

I. PERSALANE.	*Victorare*	*Belgare* Acid porphyre Dacyte Greisen Rhyolyte	*Columbare* Aplyte Granyte Obsidian Porphyry Rhyolyte	*Brittannare* Andesyte Aplyte Dacyte Granyte Grano-dioryte Obsidian Porphyry Qu. dioryte Rhyolyte	*Canadare* Andesyte Anorthosyte Litchfieldyte Neph.-syenyte Pulaskyte Rhomben-porphyry Soda syenyte Syenyte Trachyte	*Russare* Leuc.-phon. Leuc.-ting. Miascite Neph.-porphy. Neph.-syen. Phonolyte Tinguayte	*Tasmanare* Foyayte Neph.-porph.	*Ontarare*	
II. DOSALANE.			*Hispanare* Cordieryte-andesyte Pantellaryte	*Austrare* Andesyte Dacyte Granyte Grano-dioryte Latyte Monzonyte Pantellaryte Qu. dioryte Rhyolyte Syenyte	*Germanare* Andesyte Basalt Diabase Dioryte Gabbro Kersantyte Latyte Monzonyte Porphyryte Syenyte Trachyte Umptekyte	*Norgare* Borolonyte Essexyte Hornb.-gabbro Laurdalyte Neph.-syen. Solvsberg Tinguayte	*Italare* Ijolyte Leucityte Lujavryte Tephryte	*Campanare* Vesuvian lava	*Lappare* Leucite-syenyte Sussexyte Urtyte
III. SALFEMANE.			*Atlantare* Pantellaryte Rockallyte	*Vaalare* Basalt Diabase	*Gallare* Absarokyte Basalt Camptonyte Diabase Gabbro Kentallinyte Kersantyte Monchiquyte O. monzonyte Orendyte Shonkinyte	*Portugare* Camptonyte Essexote Leucyte-bns. Limburgyte Monchiquyte Nephelinyte Shonkinyte Theralyte Wyomingyte	*Kamerunare* Limburgyte Malignyte Neph.-basalt Nephelinyte Ouchityte Theralyte	*Bohemare* Ijolyte Leucityte Melilyte-basalt Missouryte	*Finnare* Ijolyte
IV. DOFEMANE.	*Fungarare* Cortlandyte Gabbro Lherzolyte Limburgyte Missouryte Noryte Periodyte Picryte	*Scotare* Basic-Neph.-B. Gabbro Melilyte-bas. Periodyte	*Sverigare* Ilmenyte-nor. Melilyte-bas.	*Adirondackare* Iron ores					
PERFEMANE.	*Maorare* Dunyte Harzburgyte Lherzolyte Noryte Periodyte								

As an example of the working of the method, the monzonyte—an augite syenyte from the Monzone in the Tyrol—is selected. This, it may be stated, is a granular, moderately coarsely crystalline rock, composed essentially of feldspars, pyroxene, and hornblende, with some biotite, a little quartz, and insignificant amounts of magnetite and apatite. The silica alumina—*salic*—minerals dominate over the iron magnesian—*femic*. It therefore belongs to class 2, above—the do-salic, or *dosalanes*. Since neither quartz nor the feldspathoids (lenads) are present in essential quantities, it belongs to the 5th order and is, *germanese*. Both of these references could in this particular instance be made from megascopic examination in the field. The ratio of the alkalies to lime, as shown by chemical analyses, relegates the rock to the second rang, the dominant alkalic (domalkalic), for which the name monzon*ase* is proposed, while the nearly equal proportions of potash and soda causes it to be referred to the sub-rang monzon*ose*.

Further refinement is possible through a consideration of the relative proportions of the subordinate minerals. From the illustration, it thus appears that our old acquaintance is hereafter to be found among the polynomial hyphenated throng and to show, if not pedigree, at least social standing and position, all in a name. Thus, if met with casually in the field, it is a *biotitic-hornblende-grano-dosalane,* but as we become intimately acquainted, we may, through more attentive study, be enabled to still more closely define its social standing and introduce it to our intimate friends—those of our own mental standing—as a *biotitic-hornblende-grano monzonose.*

However cumbersome such a system and nomenclature may at first seem, it certainly has the advantage of putting one at once in possession of all the salient points of character in a rock mass, and should new peculiarities develop on further acquaintance, other hyphens are provided, such as shall meet all possible requirements. Moreover, cumbersome as the names may seem, they are, after all, little more so than some now in use—*porphyritic hornblende-biotite granite,* for instance, and surely they are preferable to such meaningless terms as *shonkinyte* and *laurvikyte.*

To one not in the front rank in petrographic work, the amount of calculation and detailed chemical and mineralogical

work involved in relegating a rock to its proper place in the system may at first seem appalling. Nevertheless, it must be remembered that, but a few years ago, the feeling prevailed that the modern method of petrographic study could never come into general use, owing to the difficulty and expense of preparing thin sections.

Tables and illustrations of the methods of calculation are provided which, however formidable they appear, unquestionably afford a way out of the existing confusion and indefiniteness. The petrologist who adopts the system is enabled to state his results definitely and with precision. It is possible, even necessary, for him to show by his nomenclature how thorough and exhaustive has been his work. The system is unquestionably a possible one, and one capable of indefinite refinement and expansion, as the needs of the science demand. As to its general acceptance, time alone can tell.

It may be well to add in this connection that Dr. Washington has prepared, with especial reference to the new system, a compilation of all rock analyses made since the time of the last edition of Roth's Beiträge zur Petrographie, etc. (1884). This work, it is understood, is nearly ready for publication.

G. P. M.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

On Batrachian and other footprints from the Coal Measures of Joggens, N. S. By G. F. MATTHEW, LL.D., etc. [Bull. Nat. Hist. Soc. of New Brunswick, Vol. V, No. 21, 1903.]

Some small footprints from the Coal Measures of Joggins, Nova Scotia, which proved so fruitful a locality for the remains of small Microsaurians under the search of the late Sir W. J. Dawson, show that the interest of this locality is not exhausted.

The Batrachian tracks are three in number, and the species are referred to the genera Thenaropus, King, and Baropus and Dromopus of Marsh. One of the tracks is supposed to belong to King's genus above mentioned but to be prints of the forefoot only. The other two are in consecutive series and show well the mode in which these animals progressed. One had a somewhat heavy tread and some of the

toes had claws, impressions of claws, the other and smaller species appear to have no claws, but is thought to have been made by a more active animal. A track of a Myriapodites is also described.

A halftone plate exhibits accurately the form and relief of these little footmarks. There is also a description and figure of a Myriapotus.

G. F. M.

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Marl-Loess of the Lower Wabash Valley. (Bull. Geol. Soc. Am., Vol. 14, pp. 153-176, April, 1903.)

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An Excursion to the Plateau Province of Utah and Arizona. (Bull. Mus. Com. Zoology, Cam., Mass.)

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Marl-Loess of the Lower Wabash Valley. (Bull. Geol. Soc. Am., Vol. 14, pp. 153-176, April, 1903.)

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New forms of Sperrylite. (Am. Jour. Sci., Vol. 15, June, 1903, pp. 450-459.)

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New Term for the Upper Cambrian Series. (Jour. Geol., Vol. 11, No. 3, April-May, 1903, pp. 318-320.)

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CORRESPONDENCE.

BITUMINOUS AND ASPHALT ROCKS OF THE UNITED STATES. The Twenty-second Annual Report of the U. S. Geological Survey, 1901, part 1, pages 211-452, inclusive, contains a report on Bituminous and Asphalt rocks of the United States by George H. Eldridge.

On page 259 of this report he makes a statement that the region around Higginsville and Odessa are the only portions of Missouri where bituminous rock has thus far been found. Now if he had consulted the Missouri geological reports or the persons most familiar with Missouri geology his published report might have been more complete and correct. I have mentioned the occurrence of bituminous rock in seven published volumes between 1872 and 1898 recorded in authorized state and United States publications and in periodicals and journals of scientific societies. I mentioned it in five places in the Missouri geological report for 1872 and fourteen places in the geological report for 1873-74. In Vol. 8, for 1895, are three pages and in Vol. 12, for 1898, there are four pages devoted to the discussion of bitumen in Mis-

souri. In the Trans. St. Louis Ac. Sc., Vol. 3, Sept., 1874, there are three pages treating of bitumen in Missouri. In "Reports and Awards of Group I," International Exhibition, Philadelphia, 1876, pages 9 and 10 are devoted to the discussion of oil and bituminous rock in Missouri. The Kansas City Review of Science and Industry, Vol. 1, for 1877, on pages 216 and 217, contain notices of the occurrence of oil and bitumen in Missouri.

Bitumen and bituminous rock have been found in ten counties in Missouri, from Caldwell on the north to Newton county in the south, and in a belt of from twenty-five to forty miles in width in Missouri, and a vertical geological range of over 600 feet more or less. In this district five wells over 700 feet in depth have been bored for oil revealing rock highly saturated with bitumen (See Geol. Reports for 1872 and for 1873-74). Considerable gas was met with in some of these wells, and in some a strong brine. This oil zone extends westward into Kansas and southwardly into Indian Territory and beyond.

To say the least, that report was a careless piece of work.

Columbia, Missouri, May 18, 1903.

G. C. BROADHEAD.

PERSONAL AND SCIENTIFIC NEWS.

MR. FRED B. MOFFET has been appointed geologist by the U. S. G. S. to go with a party of topographers to Cape Nome, Alaska.

MR. H. W. SHIMER, OF COLUMBIA, will go to the Institute of Technology as instructor in Palæontology and stratigraphic Geology.

MR. GAY M. HAMILTON of the University of Nebraska has been elected instructor in geology in the New Mexico School of Mines.

MR. D. W. JOHNSON, FELLOW IN GEOLOGY at Columbia University has been appointed instructor in Geology at the Institute of Technology, Boston.

LEON DOMINIAN, B.A., graduate student in the Mining School of the University of Liege, Belgium, has been appointed instructor in the New Mexico School of Mines.

DURING THE COMING YEAR, at the New Mexico School of Mines, an extended course of lectures on Mining Law will be given by the Hon. Daniel H. McMillan, Judge of the United States District Court.

THE EASTERN BRANCH OF THE FIELD GEOLOGY of Columbia University will be held this year at Larabee Point, Lake Champlain, N. Y., during the first week in June. The six weeks' Summer School in Geology begins July 6. Courses will

be given by professor Grabau in general and in historical geology.

PROFESSOR C. L. HERRICK, formerly of Chicago University, and later president of the State University, will, during the ensuing year, deliver a course of lectures on geological philosophy in the New Mexico School of Mines. Dr. Herrick is now largely interested in mining in New Mexico and is one of the *doctrinaires* who has been eminently successful in business affairs.

ROYAL P. JARVIS, M.E., has been appointed professor of Mining in the New Mexico School of Mines. Mr. Jarvis has for the past three years been connected in the capacity of superintendent, with the Compania Metallurgica de Torreon in Mexico. Previously he had had wide experience in Colorado fields, principally as chief chemist and assayer of the Bimetallic Smelting Co., of Leadville; and in Peru, South America.

PROFESSOR RUFUS M. BAGG has been appointed to fill the chair of mineralogy and petrography in the New Mexico School of Mines. Dr. Bagg is a graduate of Amherst College and Johns Hopkins University and is exceptionally well equipped for the post to which he has been called. He has had wide experience in practical mining work and was mineralogist in the department of mining and mineralogy for the Commissioner General of the United States to the Paris Exposition.

DR. ROBERT N. HARTMAN, who was asphixiated in the chemical laboratory of the Colorado School of Mines a few days ago, was one of the faculty of that school who had resigned his position there some weeks before. He had been appointed only a week to the chair of chemistry in the New Mexico School of Mines when his death occurred. He had expected to go to New Mexico in June. Professor Hartman was one of the ablest chemists engaged in mining work and the loss will be deeply felt at the New Mexico School of Mines. Doctor Hartman was a graduate of Pennsylvania College and of the Johns Hopkins University.

PROFESSOR H. L. FAIRCHILD, ASSOCIATE EDITOR OF THE AMERICAN GEOLOGIST and Secretary of the Geological Society of America, sailed for Italy, June 27. He will spend the summer in geological study in Europe, chiefly in Italy and Switzerland. He will attend the International Geological Congress in Vienna the last of August and will participate in the Pleistocene excursion through the Tyrol, returning to America early in October. His European addresses will be, to July 15, Care North German Lloyd Steamship Co., No. 11 Vico S. Antonio, Genoa, Italy; to August 15, Care Thos. Cook & Son, Schwanenplatz, Lucerne, Switzerland; to August 30, Care Thos. Cook & Son, Stafensplatz 2, Vienna, Austria; to Sept. 22, Care American Express Co., 11 Rue Scribe, Paris, France.

of these isolated limestone masses, and it is in connection with these that the copper ores are found. Contact metamorphism has not been developed to any great extent in the limestone surrounding the laccolith, but has been greatly induced in the included masses; marble, grossularite, vesuvianite and other minerals having been produced. Aside from the occurrence of the nephelite syenite in the area south of the laccolith, the region is interesting on account of the dyke rocks which are found cutting the andesite of the laccolith. Among these are found analcite-tinguaites and camptonites, as well as vogesite and diabase. Two main streams now drain the hollow formed by the down cutting of the dome where the weaker andesite has been laid bare as far as the limestone cover has been cut back."

Dr. Finlay's paper was discussed by professor Kemp, who called attention to the fact that the character of the intruded limestone was not yet entirely clear; and by Dr. H. S. Washington, who dwelt on the interest attaching to the additional localities here and elsewhere recently reported for the peculiar dyke rocks mentioned.

The second paper of the evening was by Fred H. Moffet, Columbia University, and was entitled: "The Copper Mines of Cobre, Santiago de Cuba."

In this paper Mr. Moffet said in abstract: "The copper mines of El Cobre are located about nine miles west of the bay of Santiago, where a series of eruptive flows, andesites and rhyolites, are interbedded with fragmental rocks, agglomerates, breccias and tuffs. The strike of the beds is east and west, and they dip at a low angle to the north. The series is cut by trap dykes and by two major systems of faults, the older of which runs east and west and carries with it the large ore bodies. The second major system has direction nearly north and south. Cross faults cut and displace the ore bodies of the older system, and carry copper, though in less amount. The copper workings of the old English mining companies produced enormous quantities of very rich oxidized ore which gave place in the lower levels to sulphides. Much difficulty is encountered in handling the mine water on account of the porous nature of the country rock. At the present time the iron ore of the region is of much greater commercial importance than the copper."

In the discussion which followed, professor Kemp spoke of the great importance to the United States steel furnaces which these deposits possessed on account of their great extent and convenient location. The ore is extremely low in phosphorus but contains some sulphur. The copper may again be of great importance though but little is being done at present toward its exploration.

The meeting of the Section adjourned about 9:30.

E. O. HOVEY, Secretary.

· FIG. 1. (See p. 77.)

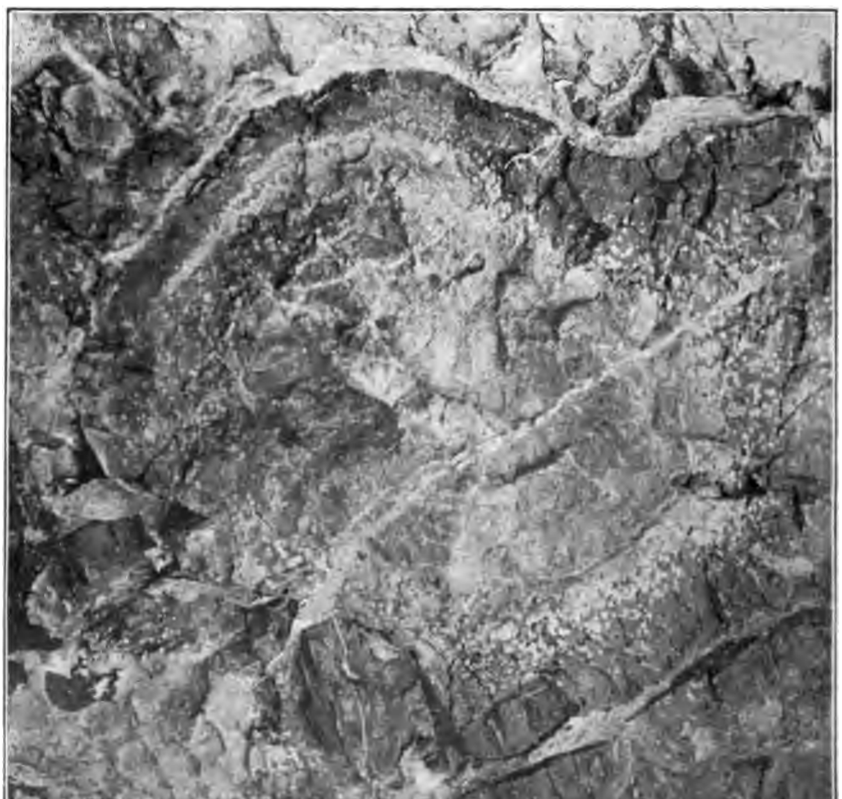

FIG. 2. (See p. 77.)

FIG. 3. (See p. 77.)

FIG. 4. (See p. 77.)

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VARIOLITIC PILLOW-LAVA FROM NEWFOUNDLAND.

By REGINALD A. DALY.

PLATES XIV–XV.

Introduction.—During the last few years there have been reported a considerable number of localities where "pillow-basalt" is to be found. The peculiar structure and stratigraphic relationships and, in several of the regions, the important volume of the rock partly explains the interest with which each new discovery has been received. The origin of the structure has also offered a problem that has aroused the keen attention of many geologists engaged in the study of the igneous rocks. Under the name of "agglomerates," "concretionary dolerite," "spheroidal basalt" or "ellipsoidal basalt," this rock has been discovered and described by workers in Minnesota, New Brunswick, California and Michigan. In the California and Michigan occurrences the lava is sometimes, though rarely, variolitic. The other known examples of pillow-lava have been found in Europe; in some of these, the variolitic habit is pronounced. So relatively limited is the total number of occurrences of both pillow-structure and variolitism in lava, that the discovery in Newfoundland of well-exposed deposits with both these features, seems worthy of record. In the following pages a brief description is therefore given of the new occurrence of this interesting and rather rare rock.

Field relations.—In the summer of 1900, the writer, as a member of a schooner expedition to Northern Labrador, was detained because of drift-ice and head-winds, in Kirpon Harbor near Cape Bauld at the extreme northern point of New-

foundland.* Short trips from the vessel on the mainland and on the adjoining islands led to the finding of pillow-lavas interbedded at several points with greatly cleaved and broken slates and sandstones. (Fig. 1 and Plate I, Fig. 1.) A deposit on

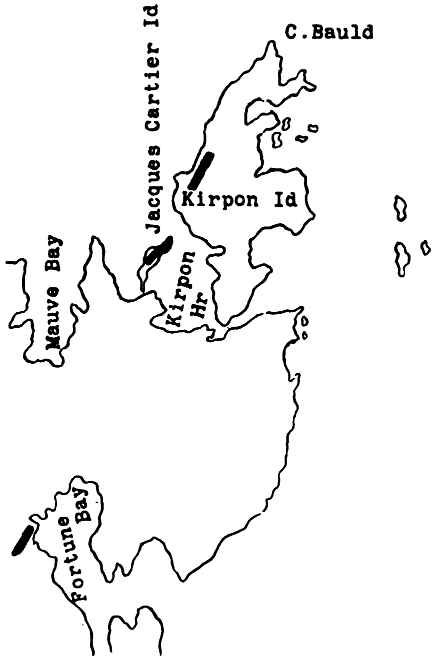

FIGURE 1.—Sketch-map showing location of the three occurrences of pillow-lava (heavy black lines) in northern Newfoundland.

Jacques Cartier Island is the best exposed, and, on account of its nearness to the schooner, could be studied in the greater detail. The description will hence refer more specifically to this one locality. The same general relations and petrographical characters, however, belong to the lava at the other localities, Kirpon Island and Fortune Bay.

The most favorable spot for determining the nature of the deposit was found at the ragged cliffs on the west side of the northern "tickle" or channel affording entrance to Kirpon Harbor. A long, deep chasm running parallel to the strike of the beds has there been worn out by wave-action. An excellent exposure has thereby been given of the pillow-lava and of the

* *Bull. Mus. Comp. Zool., Geolog. Series*, vol. v, No. 5, 1902.

underlying formation. The latter consists of black and dark gray slates with alternating dark gray sandstones and grits which form part of the normal sedimentary series underlying islands and mainland. In these no fossils were to be found but the formation is doubtless part of a lower Palaeozoic terrane and perhaps equivalent to the Cambrian across Belle Isle Strait.

Overlying the slates and in visible contact with them, is a conformable bed of light gray lava varying from 0.9 meter to 1.2 meter in thickness. This is an aphanitic rock in which the microscope shows evidence of very thorough alteration. A colorless, isotropic base seems to represent original glass. Within it are small, triclinic, polysynthetically twinned feldspars which are rather vaguely crystallized, with a characteristic poor development of the twinning trace. No other original material appears in the thin section. Both glass and feldspar are largely replaced by secondary matter which may have been derived also from pyroxene or other bisilicate phenocrysts. No trace of the latter nor of an iron ore has been found. Both the feldspar and isotropic base are shot through with needles of colorless to pale green actinolite, and are also replaced by chlorite, yellow epidote, zoisite and most abundant calcite. The whole forms a good example of an almost completely altered lava which nevertheless remains tough and relatively hard. The very poor preservation of the feldspar prevents sure identification of the particular variety present but it is probably basic andesine or labradorite. The rock may have been of a type intermediate between tachylite and normal basalt: it is vesicular at both upper and lower contacts.

Immediately above the lava sheet is the pillow lava, proved to be about 60 meters in thickness, and, in its turn, the pillow-lava is overlain by black slates, a narrow band of which appears at the water's edge just inside the entrance to the harbor. (Fig. 2.)

All these comformable beds have shared in the general mountain-building processes that have affected northern Newfoundland. With unusual distinctness of the slates about the harbor display a discordance between stratification dip and cleavage dip. At the sea-chasm referred to the two structures seem to have a common strike of about N 25° E, a direction nearly

parallel to the axis of Jacques Cartier Island and to the northwest shore of Kirpon Island. We have here, in fact, to do with almost the extreme northeasterly point which the "Appalachian trend" is known to reach. The dip of the cleavage is 70° to the ESE, corresponding to that of a system of rough, parallel joints in the pillow-lava. The dip of the bedding is but 50° in the same direction. Small dip-faults were seen in the seacliff. Greater dip-faults of considerable but unknown throw cut off the entire series along the axis of the "tickle" and again at a point about 370 meters to the southeast of the headland at the sea-chasm.

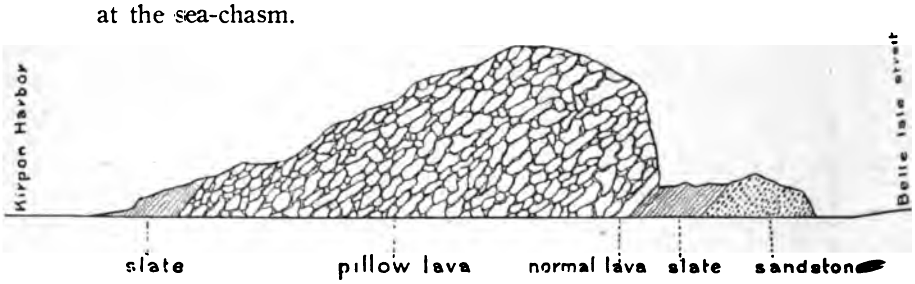

FIGURE 2.—Dip-section at northeastern end of Jacques Cartier Island, looking southwest. Horizontal scale, 130 feet to the inch; vertical scale, 100 feet to the inch. Size of pillow exaggerated.

Structure of the pillow-lava.—The pillow-lava, on account of its unusually good exposure and remarkable structures, occupied most of the short period of time which was granted for the investigation of these rocks. The accompanying illustrations, together with the accounts of pillow-lavas by Gregory, Ransome, Teall, Peach and Horne, and others, will render superfluous a complete verbal statement of the features characterizing the deposit. It is composed throughout of round, generally smooth, "bale-like," "pillow-form," commonly ellipsoidal masses of lava. (Plate XIV, Fig. 2.) These are discontinuous and perfectly individualized as a rule. They range from 5 cm. to 2 meters or more in greatest diameter. The interstices between them, including the conspicuous triangular spaces occurring where three or more pillows meet, are filled with coarsely crystallized calcite, quartz and dark, cherty masses. Those minerals thus form a sort of attenuated cement for the whole deposit. Calcite and quartz, chiefly the former, likewise fill joints and the extremely numerous cracks that appear in roughly radial arrangement within each bolster-like mass.

The radiating cracks were often seen to be widest and most numerous in the center of the pillow, recalling the central gaping fissures of many septaria. Such cracks are to be interpreted as due to contraction of the lava in passing from the molten to the solid state. The outer surfaces of the pillows occasionally show the "bread-crust" form, and generally the entire surface of each pillow and the crust forming the outer 2 cm. to 10 cm. of the mass are highly vesicular after the pattern of ordinary basalt flows. The corresponding amygdules are filled with calcite or, more rarely, with chlorite, chalcedony

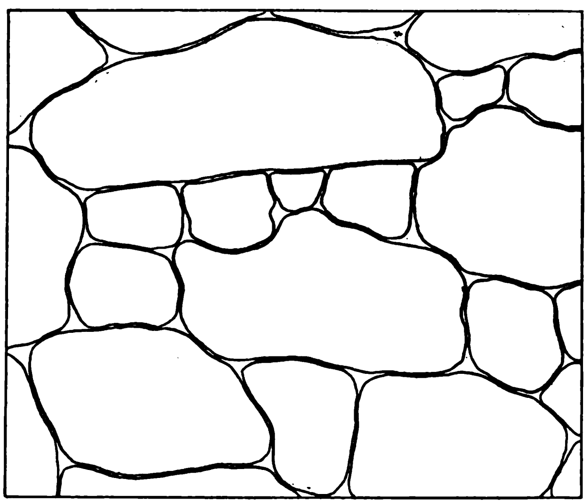

FIGURE 3.—Diagram of strike section in pillow-lava, Jacques Cartier Island. Scale 1 : 25.

or quartz. The removal of this filling material gives the otherwise smooth surfaces of the pillows a pitted look. The pillows are also similar to those of California, Minnesota, Scotland, the Fichtelgebirge, etc., in showing plain evidence of their having been once sufficiently molten to yield somewhat to the action of gravity. The surfaces of contact are often sympathetic, an indentation of one nicely matching a protuberance from the pillow adjoining. Sometimes a large, overlying pillow will be seen to lie on a sort of pavement made up of a half-dozen or more smaller ones flattened on their upper sides parallel to the longer axis of the larger pillow. (Fig. 3.) The flattening of the larger pillows almost invariably causes them to

lie concordant with the true dip of the slates alongside. In some cases the surfaces of single pillows, weathered out from their calcite matrix, were seen to have the exact appearance of ropy lava.

A microscopic feature that especially distinguishes this pillow-lava is found in the appearance of two distinct kinds of material, which, in addition to the amygdule fillings, composes each of the pillows. In most of the small ones the chief constituent is a dark, brownish-gray or greenish-gray, aphanitic, basaltic-looking rock substance continuous from center to circumference. Within it, numerous round, light-gray to light greenish-gray bodies from 2 to 15 millimeters in diameter, lie embedded. (Plate XV, Fig. 3.) These bodies are less rapidly destroyed by the weather than their matrix and hence usually project so as to give the rock a "pimply" appearance. There is always a sharp line of demarkation between the two kinds of material, indicating that the differentiation of the two dated from the time of original solidification. The lighter-colored included bodies are, in fact, believed to be varioles, though it will be seen that, in their present highly altered condition, some of the characteristics of true varioles are absent. There is a marked increase in the size and abundance of the varioles with increasing distance from the periphery of the pillow. In that phenomenon is to be traced a connection with the yet more abundant pillows in which the core of each is occupied by a continuous mass of the variole substance. (Plate XIV, Fig. 2.) This common feature of the Newfoundland rock does not seem to belong to the well-known variolitic pillow-basalt of Mont Genèvre, although, in other respects, there is a close resemblance between the two lavas. All transitions may be seen from the pillows of the first class to those where the variole substance composes as much as one-half to three-quarters of each pillow. The latter proportions adhere more especially to the large pillows. In no case was the variole substance apparent at the surface of the pillow. As at Mont Genèvre the varioles are generally arranged in concentric strings roughly parallel to the pillow-periphery. Near the light-gray core the varioles often anastomose and may form branching vermiform projections from the core into the dark-colored crust. While the isolated varioles are commonly spherical or nearly so, it was observed in

several instances that they were flattened so as to lie parallel to the true dip, i.e. in the same sense as the pillows themselves.

Petrography.—The rock in the field is apparently fresh and it was expected, in view of the intense glaciation this region has suffered and because of the rapidity of wave-erosion at the sea-chasm, that extensive alteration of the lavas through weathering had not taken place. It was therefore hoped that the microscope would throw light on the origin of the peculiar differentiation of matter in the pillows. But every thin section studied showed that both varioles and matrix have suffered almost complete decomposition.

The aphanitic matrix is, in thin section, nearly colorless, with a pale green cast. It consists of a confused, structureless, massive mat of obscure feldspathic material, accompanied with exceedingly abundant calcite and with many ragged colorless tremolite or actinolite crystals, much chlorite, zoisite and abundant yellow grains of epidote. Very rarely one or two minute grains or idiomorphic crystals of magnetite will appear in a slide. Finally, numerous colorless, isotropic areas occur between these various minerals. Such areas may represent original glass, though some of it suggests opal and infiltrated chalcedonic silica. Maximum extinctions in the zone of symmetry of the feldspars showed values of about 17°, indicating andesine. The feldspar is often characterized by radial aggregation. With the magnetite and the rather doubtful glass, it represents the only original matter in the matrix.

The varioles seem to be even more completely made up of decomposition products. The most prominent constituent occurs in the form of long, frayed-out skeleton-crystals, shot through the generally ground-mass like phenocrysts in an igneous base. These crystals vary from 0.1 mm. to 1.0 mm. or more in length and from 0.02 to 0.25 mm. in width. They are generally bleached to a colorless condition with a corresponding feathering out into irregular needles of tremolitic habit, but, here and there, green and rather strongly pleochroic areas, with the characters of actinolite, merge into the colorless amphibole. It is believed that the skeleton-crystals represent highly altered actinolite crystals. On account of decomposition, they rarely show amphibole cleavage in sections transverse to the longer axes of the skeletons. Along with the bleaching of

most of the little amphibole substance still remaining, there has occurred within the limits of the skeleton-crystals, the extensive generation of chlorite, zoisite, calcite, chalcedony, and abundant, single and aggregated, grains of yellow epidote. The skeleton-crystals sometimes, though rarely, show a tendency to aggregate in either of two ways. They form small radial groups irregularly placed at intervals in the variole, or a number of the individual crystals may in the section, lie roughly parallel to one another in a manner very similar to that of the small, colored pyroxenes forming "palisade-structure" in the varioles of the Annalong dike of Sollas.* The analogy between the Irish and Newfoundland varioles is so striking that one is tempted to regard the skeleton-crystals of the American rock as pseudomorphs after pyroxene. Basal sections have irregular octagonal outlines similar to those of phenocrystic augite. No trace of that mineral has been found, however, and one can go with certainty no further back in tracing the history of the skeletons than to the amphibole stage antedating the existing masses of secondary material.

The ground-mass in which the skeleton-crystals are embedded, is a confused mesh of minute, relatively long, needles of tremolite or bleached actinolite, matted together with abundant chlorite, chalcedonic silica, epidote, zoisite, quartz, and, apparently, minute apatites. With the exception of the last-mentioned mineral, of whose presence, indeed, the writer is not entirely certain, all this substance is plainly secondary. No trace of feldspar, or pyroxene and generally no iron-ore of any kind was to be discovered in the varioles. In one slide a couple of minute grains of magnetite probably represent primary material. There seems to be a relation between the size of the varioles and the length and thickness of the skeleton-crystals. The larger varioles so far as examined in thin section, contain the longest and broadest skeletons.

Chemical analyses have not been made, since they could throw but little light on the original nature of the variolite. The character of the decomposition products, the relation of the varioles to the matrix, to the aphanitic crust and to the periphery of each pillow, are so closely similar to the variolite of

* *Proc. Roy. Dublin Soc.*, vol. vii, 1892, p. 516.

the Fichtelgebirge,* of Point Bonita,† of the Lleyn‡ and of Mont Genèvre,§ that there can be little doubt that the Newfoundland pillow-lava is a basalt or at least that it is no more acid than an augite andesite. Using Rosenbusch's designation for these special basaltic rocks, the Newfoundland lava may be called a greatly altered, variolitic spilite possessing the peculiar ellipsoidal or pillow structure.

The strike and other field relations, except the angles of dip, as well as the petrography of the thick deposits seen on Kirpon Island and at Fortune Bay, (dip nearly vertical) are essentially identical with those just detailed for the rock on Jacques Cartier Island. It is, in fact, believed that, notwithstanding the fault at the entrance to Kirpon Harbor, that the outcrops on Jacques Cartier Island and Kirpon Island belong to the same deposit. In all three localities, the pillow-lava is more resistant to the weather than the associated slates and sandstones, and forms strong ridges in the topography.

The Origin of Variolite.—Much has been written concerning the causes underlying the development of varioles in basic rocks. It is clear that the Newfoundland occurrence cannot, on account of the all but complete decomposition of the rock, throw much additional light on this question. From the sharpness of the boundaries between variole and matrix and from the well defined difference of habit of the sets of secondary minerals composing the two elements of the rock, one must conclude that the varioles are, in date of formation, to be referred to the period of cooling of the lava from its once molten condition. The studies of the European variolites have indicated, too, the strong probability that in the development of the varioles, there is little, if any, chemical differentiation in the magma. Loewinson-Lessing suggests that the causes are probably external, as for example, rapid cooling *per se*, but concludes that the causes are really unknown.‖ Cole and Gregory say: "The variolite of the Durance occurs *in situ* as a selvage on the surfaces of these diabases among themselves as blocks in the fragmental rocks, which are regarded by us as tuffs; and occasionally as a selvage to the diabase dikes. This product of

* J. W. Gregory. *Quart. Jour. Geol. Soc.*, vol. xlvii, 1891, p. 45.
† F. L. Ransome. *Bull. Dept. Geol. Univ. Calif.*, vol. i, 1893, p. 71.
‡ Miss C. A. Raisin. *Quart. Jour. Geol. Soc.*, vol. xlix, 1893, p. 145:
§ G. A. J. Cole and J. W. Gregory. *Ibid.*, vol. xlvi, 1890, p. 295.
‖ *Tscher. Min. und Petrog. Mitth. Neue Folge*, vol. vi, 1885, p. 299.

rapid cooling was originally a spherulitic tachylite, and has become devitrified by slow secondary action. Variolite stands in the same relation to the basic lavas as pyromeride does to those of acid character."* Gregory concludes from his study of the Berneck variolite in the Fichtelgebirge, that, "though the varioles be the product of rapid cooling, too sudden a solidification of the diabase may prevent their formation. For a similar reason the amygdaloidal is less variolitic than the compact diabase, the loss of water that occupied the vesicles having diminished the fluidity of the rock."† A review of the literature dealing with variolite seems to show that it is best developed within "ellipsoidal" or pillow-lava, though a goodly number of instances are on record showing that the structure may appear just inside the glassy selvage of quickly cooled diabase dikes. In the paper of Cole and Gregory just quoted there will be found a full set of references to the previous investigations of variolite.‡ In North America, two occurrences, both in pillow-lava, in addition to this one from Newfoundland, have since been described by Ransome§ and Clements.‖ In Europe several new localities have afforded examples of the rock. Cole has noted variolitic diabase in Anglesey¶ and in County Down, Ireland;° Sollas, variolitic diabase in Wicklow County, Ireland;′ and Miss Raisin variolitic pillow basalt from the Lleyn, Wales.″

The phenomena at all these localities seem to bear out the general conclusions of Cole and Gregory. Although there is but little direct microscopic or chemical evidence on the point, it seems justifiable to apply their explanation of the variolitic structure to the Newfoundland rock. The identity of decomposition products in variole and matrix certainly argues against any significant chemical differentiation in the magma at the time of variole-formation.

The Origin of the Pillow Structure.—In the latest important publication on pillow-lava, Clements has given a useful review and bibliography of the subject. He has considered the

* *Quart. Jour. Geol. Soc. London*, vol. xlvi, 1890, p. 331.
† *Ibid.*, vol. xlvii, 1891, p. 61.
‡ *Op. cit.*, p. 327.
§ *Op. cit.*, p. 99.
¶ *Monograph U. S. Geol. Surv.*, vol. xxxvi, 1899, p. 108.
‖ *Proc. Roy Dublin Soc.*, vol. vii, 1891, p. 112.
° *Ibid.*, 1892, p. 511.
′ *Ibid.*, vol. viii, 1893, p. 94.
″ *Op. cit.*

Locality	Describer	Year of publication	Geological Date of Eruption	Immediately Associated Sediments	Author's Theory of Origin	Remarks
New Brunswick	Ells	1879	Lower Silurian	Graptolitic slates	Concretionary dolerite	
Mont Genèvre, France	Cole and Gregory	1890	Post-Carboniferous	None	Bombs and rolled out pahoehoe	Variolitic
Aci-Castello, Sicily	Platania	1891	Post-Pliocene (?)	Clays	Due to intrusion into submarine silt	Variolitic (?)
Berneck, Bavaria	Gregory	1891	Post-Devonian	Shale and slate	Due to contraction	Variolitic
Ely, Minnesota	Winchell	1892	Pre-Cambrian	Jasperoid iron-ore and silicious schists	Agglomeratic acccumulation	
The Lleyn, Wales	Raisin	1893	Probably early Palaeozoic	Argillite?	Due to contraction	Variolitic
Pt. Bonita, California	Ransome	1893	Cretaceous (San Francisco Sandstone)	Red jasper	Viscous pahoehoe	Sometimes variolitic
Mullion Id., Cornwall	Fox and Teall	1893 and 1894	Palaeozoic (Ordovician)	Radiolarian cherts	Submarine flows of lava, partly intrusive into bottom silt	
Angel Id., California	Ransome	1894	Jurassic or Cretaceous	Radiolarian cherts	Intrusive but near the surface	
Co. Tyrone, Ireland	Geikie	1897	Lower Silurian	Cherts, jaspers, mudstones	Intrusive into water or watery silt	
Cader Idris, Wales	Geikie	1897	Lower Silurian	Slate	Same	
Ayrshire and Forfarshire, Scotland	Geikie	1897	Lower Silurian	Radiolarian cherts and mudstones	Same	
Crystal Falls Dist., Michigan	Clements	1899	Pre-Cambrian	?	A form of terrestrial aa lava.	Sometimes variolitic

geographical distribution of the rock and also the divergent views concerning the genesis of the discrete pillow-structure.* As a supplement to his summary, the following table has been prepared, showing the already determined main facts and conclusions regarding the origin, geological age, associated sediments, and variolitism of the principal occurrences.

The later writers have taken contrasting views of origin, which, however, have this point in common, that the pillow-structure is to be connected with the presence of abundant moisture at the surfaces over which the flows occurred. Teall, Geikie and Platania credit the phenomenon to submarine eruption whereby the lava has flowed either directly into water or has been intruded into the water-soaked oozy silt of the sea-bottom. Ransome has stated his belief that the structure is not confined to surface-flows but may be found in dike-like masses intruded near the surface of a rock-series now represented by radiolarian cherts and by sandstones. Clements, on the other hand, compares the Michigan ellipsoidal basalt to the aa lava of Hawaii and Santorin and rejects Teall's hypothesis of a submarine origin. The following quotation is taken from the Crystal Falls monograph. "Both Ransome and Teall compare the ellipsoidal basalts with pahoehoe lava. The latter also suggests a submarine origin for the basalts studied by him. It should be noted that pahoehoe lava in its typical occurrence in Hawaii is found only in dry places, whereas the aa is confined to those parts of the lava stream—which in other parts of its course is perhaps developed as pahoehoe—where it crosses moist valleys or other depressions presumed to have contained a considerable amount of moisture.

"In the case of some of the block lava of Santorin described by Fouqué, with which this may be compared, the conditions were such that the lava practically welled up through the water.

"From Dana's description it appears that lava in the pahoehoe form can not exist in the presence of moisture, being changed to the aa form. It would thus seem that Teall's statement of a submarine origin for the pahoehoe lava is untenable."†

The grounds for Clements' rejection of the submarine hypothesis do not seem satisfactory to the present writer. The

* *Monograph xxxvi, U. S. Geol. Surv.*, 1899, p. 118.
† CLEMENTS. *Op. cit.*, p. 123.

facts stated in the paragraphs quoted seem, on the contrary, to point to the correctness of Teall's position. Teall doubtless meant that the *detailed* surface of the lava-pillows is more like that assumed by pahoehoe than like the ragged surface of aa blocks, a fact which is fully corroborated in the Newfoundland occurrence. (See Plate XV, Fig. 4.) In other respects certainly well recognized by Teall, pillow-lava is closely allied to the aa form. The conspicuous absence of rugosites in the pillows produced from lava welling out and rolling up into ellipsoids may be inherent in the nature of submarine aa flows. At any rate, it is in the highest degree probable that a smooth, often ropy, surface is impressed on the lower blocks overridden by an aa lava-flow. The great bulk of the units in a pillow-deposit must be compared with such blocks moulded by the weight of heavy overriding blocks rather than with the extremely cracked and rough blocks at the surface of a terrestrial lava-flow. The already well recognized common association of pillow-lavas with radiolarian cherts and with other contemporaneous marine sediments occurring above and below, and within the interstices of, a pillow-deposit, forms a strong argument in favor of Teall's view. At all of the Newfoundland localities, the lava is overlain and underlain by conformable argillitic and arenaceous strata which are without doubt the result of sedimentation in fairly deep water. The deposition seems to have been discontinuous only by virtue of the short-lived, rapid out-flow of lava on the sea-floor. That the Newfoundland lava is not intrusive into loose bottom silts in this particular instance* is shown by the apparently complete absence of argillaceous material such as would be expected to become incorporated in the mass between and within the pillows as the latter would be rudely rolled and thrust through the silt. On that supposition, moreover, it would be difficult to explain the existence of the highly vesicular, continuous lava-flow underlying the whole pillow-deposit.

Conclusion.—The writer has therefore concluded that, on the best working hypothesis, the Newfoundland rock is the product of the extrusion of basic lava into sea-water of some depth. That view is confirmed by Russell's recent dis-

* Cf. experiment by JOHNSTON-LAVIS, South Italian Volcanoes, Naples, 1891, p. 42.

covery of pillow-lava formed where the Snake River basalt ran into lake-basins.* The structure of the Newfoundland deposit is that expected in the deeper parts of the Hawiian aa flows, or may possibly be affected by as yet unknown special conditions of submarine extrusion by which each pillow has assumed the details of the pahoehoe surface. With this conception of origin there agree; the evidence of quick cooling with the incidental variolitism; the extensive radial, concentric and irregular cracking each pillow has suffered; and the profound alteration of the lava due to the easy ingress of weathering agents along the thousands of microscopic and larger cracks opened up by the rapid chilling. Next to the possession of their peculiar structure, the pillow-lavas described in Europe and America have no more prominent and unvarying characteristic than this one of manifest, profound, metasomatic alteration of the rock.

LEGENDS for *figures* and *plates*.

PLATE XIV. Fig. 1.—View of Kirpon Harbor, looking northeast. The two prominent ridges in the upper left-hand quadrant of the view, occurring, respectively, on Jacques Cartier Island and Kirpon Island, are underlain by pillow-lava.

Fig. 2.—Interior of one of the pillows, showing dark aphanitic crust, varioles, core of variolitic substance, and calcite matrix in which the pillow lies embedded.

PLATE XV. Fig. 3.—Variolite from the interior of a pillow. The scale is two inches long.

Fig. 4.—Natural surface of part of a small pillow removed from its calcite matrix, illustrating the smoothness of the pillows and the vesicular structure of the outer crust.

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* *Bull. U. S. Geol. Surv.*, No. 199, 1902, p. 113.

THE DEVONIAN ERA IN THE OHIO BASIN.

By Edward W. Claypole.

PLATES XVI-XVIII.

Part I.—Continued.

C. Geology of the Hamilton Strata.

In Ohio.—The single outcrop of the Hamilton rocks in Ohio, at Prout's Station in Erie county, has been noticed already at sufficient length. But in order to comprehend the full geology of the basin, the Hamilton as developed outside of Ohio must be considered.

Outside of Ohio.—It was noted earlier that the outline of the Hamilton sea differed very little from that of the preceding period. Certain minor differences scarcely sufficient to affect the geography have been almost entirely effaced by subsequent erosion. The Appalachian gulf retained its previous form and the northeastern embayment was a marked feature in its development.

Hypsographic changes.—But though no new or striking alteration took place in the topography, yet the change of level inaugurated in the Corniferous-Hamilton period continued after its close and indeed became more marked during the period that followed. The depression in the bed of the Appalachian gulf, forming a basin for the reception of the Marcellus shale, apparently reached a maximum in southern Pennsylvania and persisted undiminished; in the more northerly portion it even surpassed its previous limits. Hamilton-Marcellus deposits on the Pennsylvania-Maryland state-line are reported by Stevenson* at 800 feet, but in middle Pennsylvania they reach 1500 feet, as, for example, in Perry county,† where they are apparently at a maximum. In western New York their thickness is 1000 feet, or even 1200 feet, but west of this they thin out, and outside of the Appalachian gulf they rapidly dwindle down to about 250 feet, and in the far west, where an open sea prevailed and the beds are calcareous, they do not sometimes exceed 50 feet.

The main feature in the history of the basin during the period in question is therefore this settling down of its bottom over

* *Second Geol. Survey of Penna.*, T2, p. 82.
† Claypole. *Second Geol. Survey of Penna.*, F2, p. 88.

the area above outlined to form a trough or catch pit, whose greatest depth was in middle Pennsylvania and which shoaled from that point in all directions. The greatest elongation of this trough, or of so much of it as now remains, is along a line from N.N.E. to S.S.W., but its E.-W. extension has been so much obscured by subsequent folding and erosion that its original dimensions are indeterminable and not improbably its diameters in both directions were approximately equal.

Into this basin, or trough, were poured the water and the sediment brought down by the rivers from the contemporary Atlantic land. Subsidence and filling went on equally and from the nature of the deposits can be gained some knowledge of the changes undergone by the eastern shore of the gulf, which was undoubtedly the quarry from which the material was excavated.

These deposits contain, in the extreme northeast on the Hudson, a considerable proportion of sand as shown in the flagstone quarries near Kingston, etc. Hence the elevation closing the St. Lawrence channel was still proceeding and the consequent erosion was sufficient to bring off the new land the coarse sediment there characterizing the Hamilton strata. New England was still rising and increasing and its harder strata were exposed to the weather. At the same time the small thickness and extent of the flagstones show plainly that the movement to which they were due was not excessive or rapid, allowance being made for the subsequent erosion of a great part of them. The bulk of the Hamilton beds even here consists of soft material more or less calcareous. The only geographical change indicated by the geology is a progressive enlargement of the northeastern land and a partial filling of the gulf in New York.

Farther south are indications of a movement which, though also local, yet produced a marked change in the sedimentation. The Hamilton in middle Pennsylvania contains a massive sandstone, the first that we find in the column above the more massive Medina of early Silurian date. The Oriskany is thin. It underlies Perry, Dauphin, Juniata, Mifflin, Snyder, Union, Montour, Columbia and Huntingdon counties in whole or in part, with some adjacent portions of others, and may be roughly estimated to have an area of at least 4000 square miles. It

reaches its maximum thickness at or near the Susquehanna gap through the Little mountain, four miles north of Harrisburg, where its vertical beds are nearly 800 feet thick. From this point it thins off in all directions, splitting into a lower and upper division with intervening shale, as in Huntingdon county, and becoming itself more and more shaly until at a distance of about fifty miles from its center the whole sheet disappears and the Hamilton resumes its usual shaly composition*.

It is a legitimate inference from the presence of this Hamilton sandstone that somewhere on the eastern land, at no great distance, a local elevation was taking place and that from it was swept off the coarse material by some river whose mouth lay probably east or southeast of the spot where now stands the city of Harrisburg or where that spot lay before the region was subjected to the folding of the Appalachian revolution.†

What changes, if any, in the sea-margin are involved in this elevation it is not possible to determine in consequence of these disturbances, whereby the strata have been folded into close anticlines and synclines whose beds are often vertical or even overthrown, in some places severely faulted and occasionally overthrust, so that some are completely concealed by others that have been forced over them along shear-planes developed by the enormous pressures to which they have been subjected. Consequent erosion has removed all that portion that once lay to the southeast of their last outcrop at the Susquehanna gap and has destroyed the materials out of which their history could have been written.

Outside of these two areas no disturbance seems to have marked the Hamilton period. Its strata in western New York are partly calcareous, indicating a sea less clouded with shore wash and affording a typical Hamilton fauna. From this area which occupied the central portion of the gulf the sediment and the fauna gradually shade off until, as above mentioned, in the far west it is not possible to distinguish from one another the different periods of the Devonian.

In New York, however, professor Hall was able to separate the Hamilton into three parts, both lithologically and palæontologically. They are as given below:

* For further details of Hamilton, consult reports of *2nd Geol. Survey of Penna.* on the counties named, especially PERRY (F2), E. W. CLAYPOLE and HUNTINGDON (J3), I. C. WHITE.

† E. W. CLAYPOLE. *Am. Nat.*, March, 1885.

The Moscow Shale. The Encrinal Limestone. The Ludlowville, etc., Shales. But these divisions cannot be recognized at any considerable distance from his typical locality.

The Tully Limestone.—Above the topmost layers of the true Hamilton in New York—the Moscow shales—and occupying only a small area in the region of the present "finger-lakes," is found a remarkable bed of impure calcareous material, which received from professor Hall the name of the Tully limestone. Seldom exceeding ten feet in thickness, it is yet quite persistent over an area of perhaps fifty miles in diameter, separating the Hamilton strata below from the Genesee shale above it. This insignificant band would itself require little mention were it not for some interesting palæontological facts connected with it and certain important discussions to which the facts have given rise.

All attempts to identify the Tully limestone beyond the small area around the "finger-lakes" has failed. Professor N. H. Winchell thought that he had discovered it in Ohio, and in his report on Delaware county he says:

"The shaly limestone near the base of the Olentangy shale is immediately underlain by a very hard crystalline limestone which is sometimes black, but frequently purplish, containing pyrites in abundance, but very few evident fossils.—In the report on Marion county it has been referred to the Hamilton, where it probably belongs, and seems to represent the Tully limestone of New York."*

But Dr. Newberry comments on the above passage thus in a foot-note:

"The Tully limestone of Prof. Winchell's sections is certainly Hamilton, as I have obtained from it *Tropidoleptus carinatus, Pterinea flabellum, Nyassa arguta, Spirifer mucronata*, etc. That it is the equivalent of the Tully limestone is not indicated by any evidence yet obtained."

Again, in his report on Montour county, Penna., professor White, speaking doubtfully, says:

"The Tully limestone is identified in this region only by its appearance, its fossils being the common Hamilton forms. But as the beds immediately above it are certainly the representatives of the Genesee there can be no impropriety in referring it to the Tully horizon."

The wisdom of professor White's caution can scarcely be doubted on examining his list of fossils. On a later page (289) he says:

* *Geol. of Ohio*, vol. ii, p. 288.

"The Tully limestone contains none of the Tully fossils found in New York, but merely the common Hamilton forms, as identified by Prof. Claypole:"

Atrypa reticularis,
Spirifera fimbriata,
Chonetes setigerus,
Dalmanites calliteles,
Ambocoelia umbonata,
Spirifera ziczac,
Phacops rana.

Evidently, therefore, the Tully limestone is only a local deposit in the north-central part of the Appalachian gulf where, for the time, mechanical sediment was lacking and an opportunity for calcareous deposition recurred. This was probably due to a low level of the surrounding land when the elevation which had given rise to the heavy shales and the thick Pennsylvania sandstones had ceased and the elevated country had been degraded so that the currents of the rivers were slackened and the erosion had become weak.

But though it may not be difficult to account for the intervention of a small thin bed of limestone at the top of the Hamilton group in New York, yet there remain other problems less easy of solution. What caused the sudden and considerable change of fauna at the base of the Tully? What also caused the extinction of a great part of the Tully fauna at its summit?

The Tully Fauna.—No one has studied the mid-Devonian fauna of northern Appalachia with greater assiduity or persistence than professor H. S. Williams, of New Haven, who presented an elaborate argument on the closer relationship of the Upper Devonian fauna of Appalachia to the Lower Devonian fauna of Europe than to that of eastern America.* This was based on the discovery of a remarkable group of fossils on Canandaigua lake showing a strong relationship to the Devonian fauna of Iowa, and differing widely from that of New York, in the midst of which it lay. After a careful study of the fossils of the Tully limestone and elimination of all the doubtful species, he selected a group of authentic Tully specimens which, from the presence among them of a form closely resembling *Rhynchonella cuboides* of Europe, he called the Cuboides fauna.

Continued investigation led to the conclusion that in eastern America, where the Tully appears, the fauna of the Cuboides zone begins abruptly and from it upward all through the Up-

* WILLIAMS. Scope of Palæontology, *Proc. A. A. A. S.*, 1892, and AMER. GEOL., Sept., 1892.

per Devonian is a fauna closely related in its species with the Upper Devonian of western Europe, Russia, Siberia, China and British America, and down as far as Iowa in the interior the Nevada Devonian also showing close affinities with this type.

But in western Europe, where the statistics are abundant and clear, and, so far as evidence bore on the case, also in Russia, Asia and British America, the Cuboides fauna is the natural successor of the middle and lower Devonian of those regions.

In his view, therefore, the Upper Devonian fauna of Appalachia is descended from a fauna which migrated into the region at the close of the Hamilton period from the northwest, and which had previously occupied not only the northwest part of this continent, but also Siberia, Russia, China, etc. The earlier fauna which these immigrants in part displaced was connected with and descended from one which occupied South America, the Faulkland isles, South Africa and possibly some part of Europe. He thus separates the Devonian into two areas, one chiefly in the southern hemisphere, extending from South America to Africa, and the other mainly in the northern hemisphere, extending from the region of the upper Missouri, or at least from the Mackenzie river, across Asia to Europe. He further inclines to the belief that in the earlier part of the Devonian period the Appalachian area was tenanted by the fauna of the former, which in the latter part of the same period was in great part displaced by that of the latter.

Professor Williams proceeds to strengthen his position by showing that, at the end of the Hamilton period, elevation took place in the southern part of North America, whereby a land barrier was brought into existence that cut off the Appalachian region from the former connection with the South American area, thus isolating its fauna from its ancestral stem and near relatives, and exposing it to competition with the Eurasian fauna threatening it from the northwest and, which, in the struggle which ensued, succeeded in largely supplanting it in its old home during Upper Devonian days.

Conclusions so momentous, should they be altogether confirmed and established by the further study of their author or of other geologists, will constitute one of the most important steps in the study of the American Devonian that have been thus far taken.

In order to attain the utmost certainty and exactness on the points involved the greatest caution and the most searching criticism of the arguments are necessary, and no one would more readily admit this than their author himself. And, in the further treatment of the subject, the present writer does not claim the position of a critic of professor Williams, but merely that of a fellow-worker in the same field, where the only purpose of all is the discovery and establishment of the exact truth.

With this view the following points seem worthy of consideration, of which some may be construed as in favor of and some in opposition to professor William's theory. The latter may be only difficulties which further study will remove.

1. In writing of the northeastern uplift, of which mention has been made in a preceding section of this paper, professor Williams remarks:*

"This Leptocœlia fauna extended northeastward as far as Acadia. There was evidently a barrier already separating the European sea from that of the Appalachian area and the connection with the South American faunas was by the southwest. It was as early as the age of the Oriskany that the separation of the typical southern from the typical northern faunas took place."

The present writer has assigned the separation of the Appalachian area from the northeastern and probably from the European region to a somewhat later date, probably during or at the end of the Corniferous period. That some elevation in some part of eastern and northeastern land took place in the Oriskany period is rendered certain by the existence of the sandstone. But the continuance, though in a lessened degree, of the previous strong Silurian-European aspect of the fauna is most easily explained by admitting the persistence of the old channel or channels of whose existence in earlier days little doubt has been entertained.

Moreover this is the readiest way also of explaining the occurrence of Oriskany fossils such as *Rensselaeria ovoides,* at Gaspé. It would also be difficult, on the supposition that the channel was closed in the Oriskany period, to account for the presence of a typical Appalachian Corniferous fauna far up in

* *Loc. Cit.*, pp. 165, 168.

Quebec and near the northern line of Vermont.* At the same time the increasing difficulty of communication in this direction will suffice to explain the diminishing resemblance between the faunas of western Europe and Appalachia.

2. Regarding the southern connections of the Appalachian waters, if the view set forth in the earlier portion of this paper be admitted, all communication in that direction from the inner portion of the gulf was cut off, in days long preceding the Hamilton period, by the elevation that brought the Silurian strata successively above the water-level. This uplift closed the southern bight as early as the Niagara and probably as early as the Clinton period. It must therefore have isolated the fauna from all direct southern connection almost from the beginning of the Silurian era.

Devonian Geography Southwest of Appalachia.—Further consideration of professor Williams's theory renders necessary an investigation into a somewhat wider field. It has already been shown that the Lower Devonian and Silurian strata came up successively (speaking generally) to the southward, indicating plainly a closing of any previously existing channel in that direction at the end of the Ordovician era and the progressive reduction of the water area as the Clinton, Niagara, Lower Helderberg, Oriskany and Corniferous periods passed. The evidence in favor of these changes can scarcely be invalidated, though the minor details will doubtless be subject to some alterations. It is therefore futile to look in that quarter for any channel of communication with a sea in the southern hemisphere extending over South America, the South Atlantic (Faukland isles) and South Africa. All passage in that direction was absolutely and, so far as we can see, continuously barred. The eastern shore of the gulf was certainly unbroken and the southwest therefore presented the only possible opening.

About 400 miles west of the Nashville-Cincinnati promontory rises the Ozark uplift in which the Ordovician and Cambrian strata rise to the surface, and west of this line of outcrop,

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* The following species are mentioned from this locality in the *Geology of Canada*, 1863, p. 428, from the district near lake Megantic.

Favosites gotLlandicus	*Syringopora hisingeri*
Favosites basalticus	*Diphyphyllum arundinaceum*
Heliophyllum oneidense	*Orthis striatula*
Strophomena rhomboidalis	*Spirifera gregaria*
Spirifera duodenaria	*Spirifera acuminata*
Atrypa reticularis	*Cyrtina rostrata.*

to at least the Cretaceous basin, was an old land-surface whereon no later deposits have ever apparently existed than the Ozark series. It is consequently in this gap between the Cincinnati promontory and the Ozark mountains that an opening to the southward must be found, if it be found at all.

Beginning at the base of the Silurian, the Clinton deposits skirt the western side of the promontory, appearing near the falls of the Ohio. To the westward little or nothing is known of them. Their characters are lost in those of the great mass of limestone above them, so that they cannot be certainly distinguished from the Niagara. Or, possibly, they are not present at all. From the statement that, in southern Illinois, the Niagara limestone is seen resting directly on the Cincinnati group* we may confidently infer that in that quarter the latter supposition is correct.

Farther to the westward, in Missouri, no record of the Clinton exists, but as traces of a land area are lacking it may be safer to infer that it is merged in the Niagara and at present indistinguishable from that group. In the next period the evidence is more satisfactory. Ranging southwest from the falls of the Ohio, the outcrop of the Niagara sweeps into Illinois and Missouri, where it is found both north and south of the ridge of Ordovician projecting eastward from the Ozarks. In the southern area it thickens considerably and becomes argillaceous, indicating proximity to land. But farther south it disappears, and beyond Cape Girardeau county the limestone of that name (Ordovician) comes to the surface.

The story of the Lower Helderberg is somewhat different. Also skirting the western side of the promontory it overlaps the older Silurian strata and sweeps far south through Kentucky and Tennessee to the north line of Alabama and Mississippi, where it is lost. To find it again we must pass into Missouri, where it reappears with the Niagara and is 200 feet thick in Cape Girardeau county, leaving an interval in the latitude of northern Tennessee of less than 100 miles, in the Mississippi basin, altogether unknown.

All attainable evidence tends to show that the Silurian seas never extended over the Missouri-Arkansas state-line. Moreover on both sides of the unknown region in Missouri and in

* *Geol. of Ill.*, vol. iv, p. 140.

Tennessee the formation attains its greatest thickness in the south.

Summing the above, while the facts are not clear regarding the Clinton, there is a manifest possibility that a channel to the southward existed during the Niagara and the Lower Helderberg periods to the east of the Ozark mountains and to the west of the Nashville-Cincinnati promontory which, at the most southerly traceable point, may have reached one hundred miles in width.

Passing on to the Devonian era we find in this region in Missouri a limestone mentioned by Dr. Shumard at several points and reported to contain *Spirifera arenosa.* If this identification is correct we find there an indication of an Oriskany channel as far as southeastern Missouri. The Upper Helderberg or Corniferous outcrop also runs south from the falls and then westward to the Mississippi valley in Kentucky, where it also is lost. But it is reported again with the loss, as might be anticipated, of some of its distinctive features, in eastern Missouri, and again in the southeast of the same state. The Hamilton is also reported to exist in the same place and the two groups are scarcely distinguishable. Fossils however seem to warrant the admission of both.

So far therefore as the strata can be traced, no facts forbid the belief in the existence of a channel to the southward where and when it is required by the theory of professor Williams, that is to say, during the later part at least of the Silurian and the earlier part of the Devonian eras. The scanty exposures of the rocks of these eras in northeastern Alabama are their last outcrops to the southward, but these do not forbid their farther extension under cover, and it must remain for underground exploration by drilling to reveal their actual persistence along the gap between the Ozark uplift on the west and that of Nashville on the east. The overlap of the Cretaceous and Tertiary rocks from Illinois southward conceals everything of older date in that direction.

Should the work of the geological surveys of the states of Alabama and Mississippi eventually establish the reality of the channel as required and as above indicated, it will be a striking illustration of a prophetic light cast by palæontology on a dark geological field.

Since writing the above, two papers have appeared bearing on this topic: G. C. Broadhead, AMERICAN GEOLOGIST, Dec., 1894. A. W. Winslow, AMERICAN GEOLOGIST, July, 1895.

These contributions extend the range of the great southern uplift, on which so much stress has been laid, westward over the Missouri-Arkansas area, inasmuch as they indicate that the whole region was simultaneously affected by a movement in the same direction reaching from Georgia to and beyond the Ozarks. The existence of a southern channel of communication in that direction must therefore depend on either an interruption of the uplift at that point, where it cannot now be traced, or on a previous level so low that the elevation failed to bring it above water. In the latter case, we may regard it as an exceedingly ancient forecast of the Mississippi which would then have been at least indicated in Palæozoic time.

On the whole, the evidence afforded by these writers, both well acquainted with the ground, is not favourable to the existence of a southern connecting channel at the date required by the theory of professor Williams.

Change of Sediment.—Nothing is more striking in the Appalachian history of the Devonian era than the marked change of deposits which occurred during its passage. Opening with a continuation of the great limestone strata which characterized the close of the Silurian era, it ended with one of the thickest and most extensive sheets of shales known in American geology. With this complete change of sediment came also almost as complete a change of the fauna.

The geographical development of Appalachia introduces a large estuary pouring great quantities of fresh water and sediment into the Appalachian gulf from the rising New England area. The evolution of so extensive a water system in the northeast, must, in the first place, have tended to lower the temperature of the water. A large northern river flowing from a latitude as high as that of New England into a nearly enclosed gulf previously the seat of limestone sediment and the abode of coral building polyps, could not but cool the previously semi-tropical waters and, to that extent, render them uncongenial to their previous tenants. Secondly, the consequent fouling of the Appalachian waters with a fine mud, must have contributed in no small degree to render them unfit for the con-

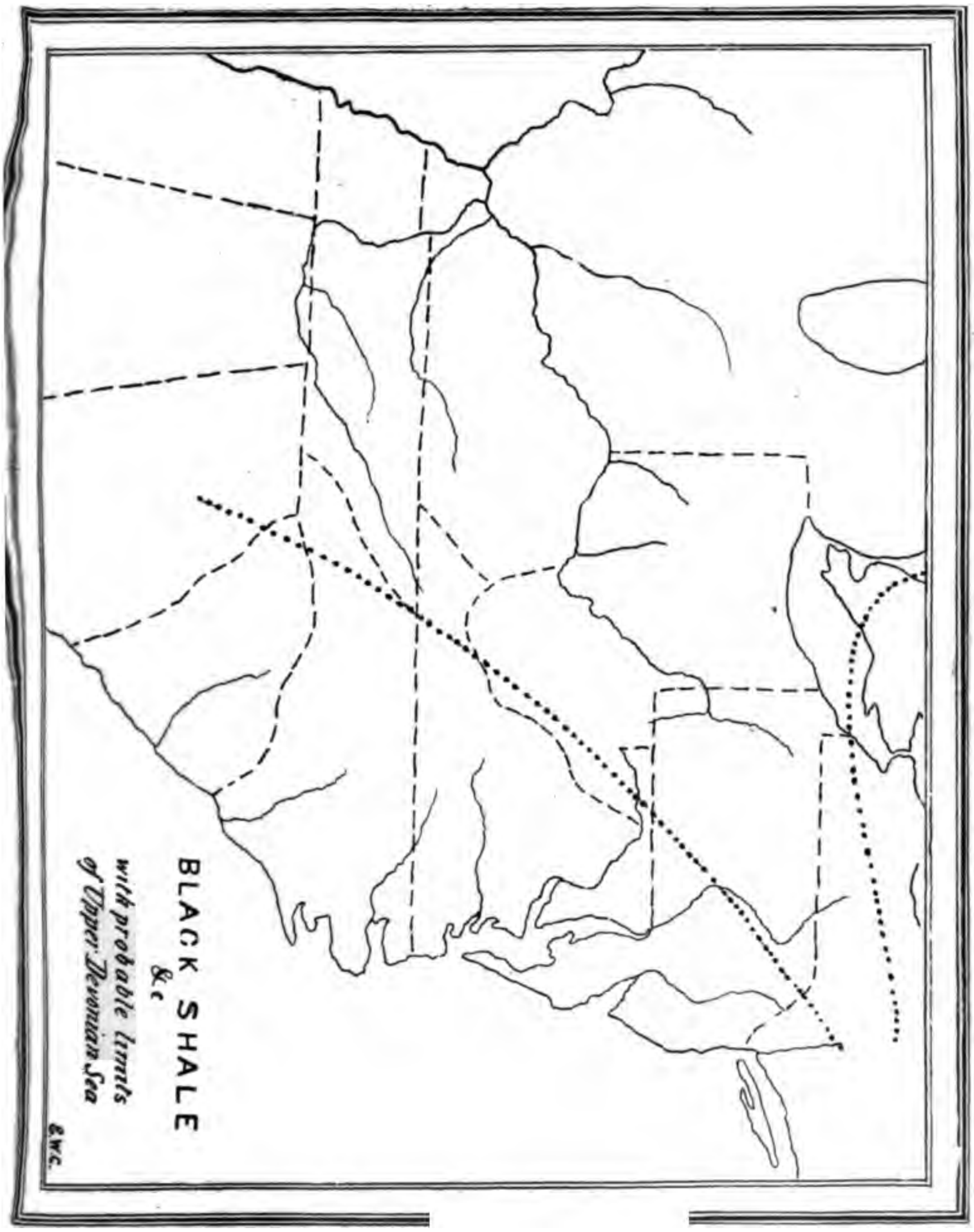
tinued existence of the denizens of the clear warm waters of the Corniferous and Corniferous-Hamilton seas, and so to handicap them in the struggle with a competing fauna, if ready to invade their area.

Two causes so important and so far-reaching as these must have at least powerfully aided in bringing about the change of fauna, at the close of the Hamilton period, which the theory of professor Williams is intended to explain, and possibly they were of themselves sufficient to accomplish it. The conditions of life—the environment—are more powerful in determining the fauna of a region than the mere possibility of communication, and if the Eurasian Devonian fauna was already as near as Nevada and western Canada, it might simply, by the changed conditions of the water and the bottom in the Appalachian gulf, be enabled to successfully invade that territory and to displace to a considerable extent its original occupants.

This physico-geographical contribution to the subject may serve as an additional means of explaining the substitution of the Upper Devonian fauna of Eurasia, in Appalachia, for that which was the direct descendant from the previous occupants of the same region.

D. THE OHIO SHALE.

All over the upper limits of the Corniferous-Hamilton in Ohio and the true Hamilton in the east of Appalachia lies that great mass of soft material which has been known as the Ohio shale. Generally speaking, this stratum is the equivalent of the Genesee, Portage, Chemung and Catskill of the east. It consists, in Ohio, of three more or less distinguishable parts, the middle one of which is the most massive and thickens rapidly from its outcrop in central Ohio to the eastward. A few local and thin sandstones of the "blue-stone" type are intercalated in the shale, but taken as a whole in Ohio and the adjoining region it is a soft mass, in which the auger descends at the rate of 100 to 150 feet daily. To the eastward the sand increases both as a diffused ingredient of the shale and as bedded rock and these included sheets of harder and porous strata are the oil and gas reservoirs of Pennsylvania and are known as the oil-sands. Beyond this to the east the shaly element further diminishes and the strata gradually merge into the almost pure sandstones of the Chemung and Catskill of the region.


BLACK SHALE
&c
with probable limits
of Upper Devonian Sea
E.W.C.

Character of Sea.—Without too closely assuming an identity with the strata of the eastern states, the lower parts of the Ohio shale must be the correlative of the beds overlying the Hamilton of New York, Pennsylvania, etc. We may safely then trace its outcrop from Canada along almost the same lines as those of its predecessor: thence through western and central New York, beyond which point it curves into Pennsylvania, traverses the central part of that state and then dives with the Hamilton beneath the Allegheny mountains. Reappearing in Ohio, it meets the line of the Cincinnati promontory, but the evidence fails to show to what extent it overlapped the earlier formations along its eastern slope. The depression in southern Ohio, where the outcrop of the Corniferous limestone and the Corniferous-Hamilton is concealed by the transgression of the shale, probably included the arch and allowed its deposition over the edges of some of the older strata. But as both have been completely removed by erosion it is not possible to determine the extent of this overlap. Its effect would necessarily be to widen the channel of communication between the gulf of Appalachia and the open western sea. This view is strengthened by the fact that the lower division of the shale retains its full thickness of about three hundred feet quite to its extreme western edge, showing no sign of the proximity of the shore.

Furthermore, the remarkable outliers at Bellefontaine, which form the summit of the state of Ohio at a hight of 1500 feet above tide, show positively that at some time during the shale period that point was under water. These scanty exposures do not at present allow a determination of the precise date of the deposit, but, considering the great erosion which has taken place, it is reasonable to conclude that the lower shale was present and that the remaining fragments belong to that division.*

On the western side of the arch the same shale continues, but there it rapidly thins down, so that in the counties near the falls of the Ohio, in Indiana, it does not exceed fifty feet in thickness. The few fossils, however, that it has furnished indicate its relationship, in part at least, to the lower portion of the Ohio shale and to the Genesee of New York.†

* The present great hight of these outliers indicates considerable subsequent elevation. Indeed, there are some reasons for believing that this elevation is still in progress.

† *Geol. Surv. of Indiana*, 1874, p. 126.

The Middle Shale.—There were no notable changes in the outlines of land and water during the middle portion of the great shale period, when, for the most part, the beds deposited were of a lighter color. This part of the mass is strictly limited to the Appalachian gulf. Consequently, on the Indiana side of the arch and beyond that line, the eighty or one hundred feet of black shale must be taken to represent the whole of the huge mass found in Ohio. Of the rapid thinning of this part of the Ohio shale as it approaches the line of the arch there can be no doubt—a proof, if any were needed, of the relative levels at that day.

The Upper Shale.—The upper part of the Ohio shale gives evidence of a wide extension of the sea beyond its previous limits. The southern border of the Appalachian gulf, which had been for ages narrowing and restricting the water-area, suddenly widens out, allowing the Upper Devonian sea to transgress its previous boundaries in that direction. Over the edge of the older strata in Kentucky, Tennessee and Alabama there lies a black shale of small thickness, but of great persistence—the only representative of the Devonian in that region. It can be traced as far south as any of the older strata and with them it disappears under the Cretaceous and Tertiary beds of the gulf states. It is involved with them in the folds of the Appalachian range in the south, but it is not seen as a black shale in their more northerly extension in Pennsylvania.

In no other direction can we detect any marked change in the outline of the Appalachian gulf in Upper Devonian days. Nor is it possible to determine to what extent the waters overflowed the Cincinnati-Nashville promontory, though there is little room to doubt that it disappeared to a very great extent beneath the waters, leaving perhaps two islands as monuments of its existence. The overlap of the shale in southern Ohio was the prophetic indication of this greater transgression in the following period, when the geography of the region was brought back for a time almost to its primeval condition in early Silurian days.

We are thus presented with a second wide palæozoic ocean, extending from the estuary of New York southwestward to an unknown distance, and possibly re-opening communication with a southern ocean, if any such then existed, by a wide chan-

nel between the southern Appalachian highlands and the Ozark uplift. As before stated, the only possible break in this immense expanse of water was caused by the survival of the Cincinnati-Nashville promontory or islands. The existence of this is doubtful during at least a greater part of the period. Though no evidence exists of the submergence of the more northern area, except what can be obtained indirectly from the higher outlier of shale, at Bellefontaine, yet the outcrop of the same shale around many of the ridges in the central basin of Tennessee, as well as on its margin, affords ample proof that, so far at least and for so long, this area was beneath the sea-level.

The long Appalachian depression which had gradually narrowed and intensified its field of action during mid-Devonian days now suddenly widened that field again and undid all that had been done in the line of elevation in the late Silurian era, submerging much that had been dry ever since that time.

The Cleveland Shale.—The reference of the Cleveland shale to the Devonian system in opposition to the view of the distinguished author of the monograph* may need a few words in its defence. It is well known that the views of the late Dr. Newberry in regard to the division of this part of the geological column were rather extreme and that he even advocated the dismemberment of the Devonian system and the allotment of the Chemung and all above it to the Carboniferous. This opinion was based more upon stratigraphical grounds than on palæontological arguments. These were also somewhat theoretical. But the changes have not found favor with his fellow-workers and the Chemung is almost invariably retained by them in the lower system.

Professor E. Orton has long maintained that the Ohio shale is not separable into distinct parts and he, consequently, discredits the divisions of Huron, Erie and Cleveland adopted by Dr. Newberry. His arguments may be found in the reports of the geological survey of Ohio, where, in its later volumes, the question recurs.

Referring in the monograph to the position taken by professor Orton, Dr. Newberry says (p. 128):

"Prof. Edward Orton, the present state geologist of Ohio, has in several of his recently published papers united the Cleveland, Erie and

* "Paleozoic Fishes of North America." J. S. NEWBERRY. *Geology of Ohio*, vol. i, part ii. Palæontology, section ii, 1893.

Huron shales and called them collectively the Ohio shale. This seems to me unwarranted, as these strata are essentially distinct in their fossils and the upper and lower members of the trinity are separated on the eastern border of the state by an interval of at least 1,000 feet."

Dr. Newberry then briefly sums up the evidence in favor of his own view, for the details of which the reader is referred to the monograph cited. We will here only remark on this controversy that it is probably too soon to assert that the opinion of either of these distinguished geologists is entitled to full acceptance and the other to complete rejection. That the clear lithological distinction between the Cleveland and the Erie, which can be seen in Cuyahoga county, extends over the whole state is exceedingly unlikely, and that the conspicuous palæontological break which marks their junction in the same region can be extensively followed is at present quite uncertain. It may accordingly, on the wide view, best suit the purpose of the stratigrapher to group the three beds together, especially as so large a portion of his data is derived, not from outcrops, but from drillings. On the other hand, the palæontologist cannot afford to ignore the break above alluded to, and must retain, at least locally, the separation of the strata until such time as corresponding fossils shall be found in the adjacent beds of the underlying Erie or middle mass of the shale. He may logically argue that so great a change in life implies no inconsiderable change in the conditions of life. The Erie shale forms a huge barrier across which no one of the fishes of the lower Huron is yet known to have passed into the upper Cleveland; and when we reflect that its western portion is quite thin, its presence seems to imply events whose results the palæontologist finds expressed in the total change of fauna.

It is unfortunate that the number of species from the lower shale is at present very small. And, until lately, this was equally true of the upper—the Cleveland. But as may be seen from the tables,* investigations recently carried on have vastly enlarged our knowledge of the latter, without revealing any trace of the lower fauna, which is as yet unknown in Ohio above the Huron shale. We are consequently disposed to agree with the author of the monograph in maintaining, locally, if not more widely, the essential distinction of the shales, while admitting the practical difficulty of separating them in the field.

* See Tables of fossils in a latter portion of this paper.

Recurring to the other topic—the date of the shales—we must maintain that the evidence on which Dr. Newberry was compelled to rely, and which induced him to refer the Cleveland shale to the Carboniferous system, was of the slenderest and most uncertain nature. He says: *

"Aside from the great fishes which are characteristic of the Cleveland shale and which, being all new species, do not decide the question, we do not have a great array of evidence. In the excellent exposures at Bedford the only fossils found are the spines and teeth of three species of elasmobranchs, *Hoplonchus, Orodus,* and *Polyrhizodus.* These three genera are characteristic of the Carboniferous system and have never been found in the Devonian, but they are hardly decisive, being specifically new. The recent efforts of Messrs. Read and Cushing have been reasonably successful, as they have found four species of brachiopods, which were reported by professor Whitfield to be *Lingula cuyahoga* Hall, *Lingula melie* Hall, and *Discina newberryi* Hall, all well known species of the Cuyahoga shale.

"The evidence, then, that the Cleveland shale is the basal member of the Waverly and therefore a part of the Carboniferous system, though not overwhelming, may be considered satisfactory."

In regard to the three fossils first named in the above extract, we may remark that the *Orodus* was found in Michigan † and can hardly be valuable evidence for Ohio. It was found in a sandstone. The *Polyrhizodus* figured is an Illinois specimen ‡ from the St. Louis limestone, no notice being taken in the monograph of the species figured in the Paleontology of Ohio and referred to the Cleveland shale, at Bedford, so that the little *Ctenacanthus* (*Hoplonchus*) *parvulus,* also from Bedford, alone remains to give uncertain testimony with the three brachiopods above cited; and in view of the enduring specific life of many of the forms of these two genera, reliance on them to decide important questions of correlation is very far from safe.

It seems to me that Dr. Newberry fails to assign full value to the important evidence of the fossil fishes. Specifically distinct as they are from those of any other formation, yet their generic and ordinal aspect must have due weight. While the *species* of the great placoderms in the Cleveland shale are totally unknown in the Devonian strata below, yet it is most significant that the *genera* themselves are absent from the Carbonif-

* *Op. cit.*, p. 128.
† *Op. cit.*, p. 106.
‡ *Op. cit.*, p. 209.

erous beds above. From no part of the world have any forms been described that could be held to indicate such a fauna as that of which *Dinichthys* and *Titanichthys* formed prominent members, while the whole ichthyic ganoid life of this shale shows no striking resemblance to that which specially characterizes the Devonian elsewhere, even the lower Devonian; so that to break up the system as proposed by Dr. Newberry would involve a loss rather than a gain in geology. And this argument gathers strength when extended beyond the Ohio basin and to Europe. Speaking for Ohio alone, it certainly appears more philosophical to draw a Devonico-Carboniferous plane, if we must have one, above the horizon of Dinichthys, than to cut that horizon in two and assign the upper part to the latter and the lower to the former of these two systems.

It is, however, in our opinion, more consonant with nature and more in harmony with modern views of life to insist less strongly on these sharp planes of division, and to regard such beds as the Cleveland shale and perhaps the next, often red, beds above it as a transition series, representing a time of passage from the older era to the newer. Life and evolution are continuous, and breaks—so dear to strict systematists—are but evidence of our ignorance.

Acting on this view, I make no attempt to define the upper limit of the Devonian in the Ohio basin, but continue the story until the general aspect of the Devonian fauna shall have definitely passed away and that of the ensuing era become established. This will probably not occur at the same horizon in different places and the faunas may justify difference of opinion, but for the area now under consideration we believe that the fossils occurring in the Bedford shale in Ohio indicate so clear a predominance of the Carboniferous facies over that of Devonia, that for that region the story may justly end with the Cleveland shale.

Similar arguments apply to the eastern side of the Appalachian gulf and warrant the termination of the Devonian history with the Catskill sandstone. The fishes of the lower rocks follow up to the top of this stratum but beyond that horizon a Carboniferous aspect becomes strikingly conspicuous in the fauna.

The consideration of this question would not be complete without regarding another element in the problem. Much material has been collected since the monograph appeared. Could its author have seen the magnificent display of elasmobranch fossils which have been brought to light by Dr. Clark, the strongly Carboniferous aspect of such a fauna would have entitled him to insist the more firmly on the allocation of the Cleveland shale on the higher horizon. With the exception of a few isolated teeth, no cladodonts were recognized from the Devonian in either hemisphere until a short time before Dr. Newberry's classic work appeared and only one or two indistinct figures were there represented. The class in aspect was regarded as essentially Carboniferous or later.

It does not necessarily follow that such allocation would have been unassailable. It may be quite as accordant with fact and with nature to carry the cladodonts back into Devonia as to move the great placoderms up into the Carboniferous. Indeed, it would be a greater incongruity to see the latter, including of course, the venerable Coccosteus, swimming in the Carboniferous sea than to recognize the cladodont sharks as denizens of the waters of Devonia.

Though only a few relics of the group were previously known, yet the presence of these few was sufficient proof of the existence of the family in pre-Carboniferous days; and when, further, we recollect that they even antedate the Devonian era itself and have left their remains in the strata of Siluria with those of the antique pteraspidians, we are forced to admit that the elasmobranch type is among the oldest vertebrate patterns that nature introduced, and may well be carried back into Devonia.

Accordingly I prefer to retain the Cleveland shale as the conclusion of the lower system, regarding it at the same time as a departure from the type toward that of the next overlying, or Carboniferous. This decision is, of course, provisional. The discovery of fossils in the Bedford shale may some day justify a reconsideration of the judgment.

In the field, in many parts of the basin, this palæontological summit of the Devonian system is not easily discovered or, indeed discoverable, and the working geologist will therefore be in practical difficulty. But the same is true on other proposed

divisions. There is no natural base in the field for Dr. Newberry's proposed separation at the top of his Huron shale. And, where the Berea grit is absent, it is not possible to find in this region any distinct physical difference between the top of the Corniferous limestone and the sandstones of the Coal Measures.

Correlation of the Shales.—Time and space forbid even a review of the many historical discussions that have taken place regarding the equivalence of the Ohio shale above the Corniferous-Hamilton and below the Berea grit. It must suffice to maintain that, as a whole, it is the contemporary of the New York series from the base of the Genesee to the top of the Catskill.

First among the problems connected with the great shale may come the changes manifested from its outcrop in Ohio to the eastward. To illustrate this topic, the accompanying series of sections has been drawn up from well-records along a somewhat irregular line traced upon the corresponding map, extending from Findlay, O., to Potter county, Penn. The diagram shows the elevation of the surface above sea-level, the thickness of the strata penetrated and the depth of the bottom of each hole, with the probable correlation of the different strata.

In thus attempting the correlation of the great shale of Ohio with the better differentiated rocks of Pennsylvania and New York, very great minuteness cannot be expected, on account of the change in their nature and the difficulty of interpreting with accuracy the numerous well-records on which most of the sections are based; and, lastly, on account of the impossibility of securing even these sections along the same straight line. Great allowance must therefore be made in the examination of the diagram, and close criticism will doubtless discover many points on which not only judgment will differ, but where the data may seem inconsistent.

The first section shown—that at Findlay—lies west of the outcrop of the Ohio shale and begins at the Lower Helderberg limestone, on which lies elsewhere the lowest of the Devonian strata. It is the record of the famous Karg well, one of the very largest gas gushers that has ever been drilled on the continent, having a capacity of twelve million cubic feet per day. The Trenton limestone was penetrated to the

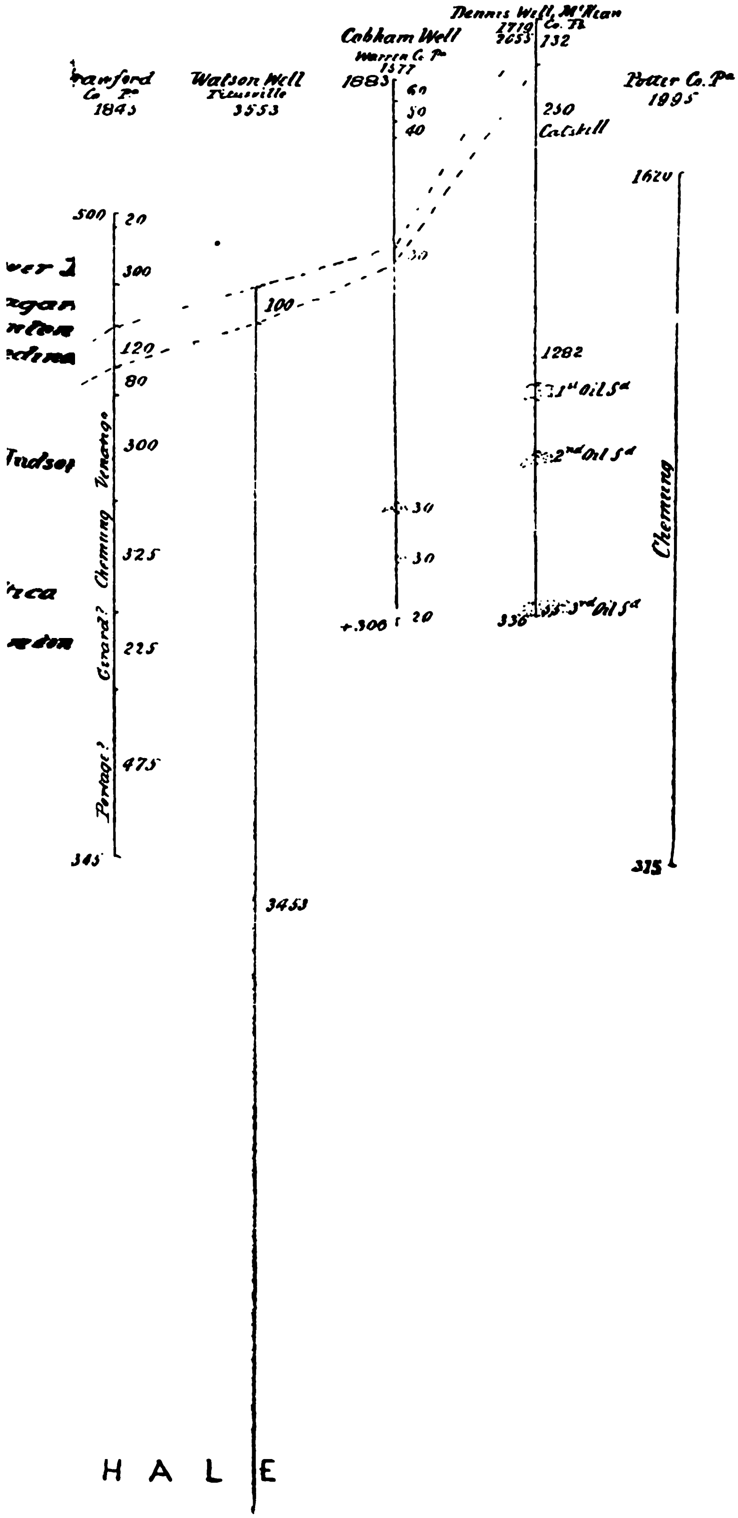
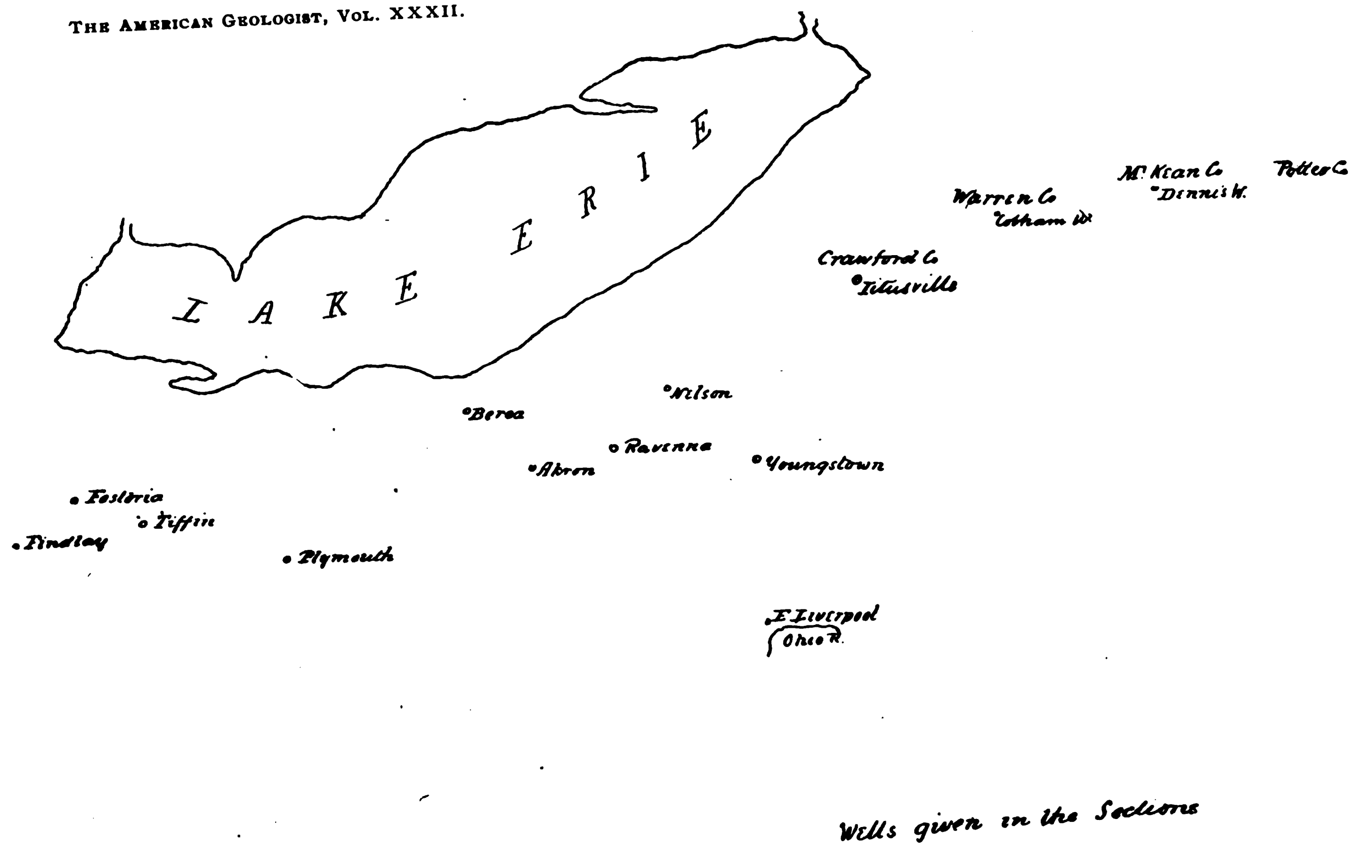

Dennis Well, M'Kean Co. Pa
Cobham Well
Warren Co. Pa
Watson Well
Titusville
3553
Potter Co. Pa
1995
Catskill
1st Oil Sd
2nd Oil Sd
3rd Oil Sd
Chemung
Venango
Gerard?
Portage?
HALE

PLATE XVIII.


LAKE ERIE
Foslória
Tiffin
Findlay
Plymouth
Berea
Akron
Ravenna
Nilson
Youngstown
E. Liverpool
Ohio R.
Crawford Co
Titusville
Warren Co
Cotham W.
McKean Co
Dennis W.
Potter Co
Wells given in the Sections

depth of about fifty feet, when the auger was unable to sink any farther on account of the enormous pressure of the escaping gas.

The second section—at Fostoria—also begins in the Lower Helderberg limestone, but the strata in the upper portion were not well differentiated in the record. The Trenton was here penetrated to the depth of 500 feet in the hope of finding additional supplies of gas, but without success.

In the next section—at Tiffin—the upper strata were not carefully noted and the top of the Trenton was only slightly penetrated. The Ohio shale first appears in the boring at Plymouth, where it is overlain by the Berea grit and, including the Bedford, reaches a thickness of 648 feet. At Berea, this has risen to 1240 feet; at Akron, to 1860; at Ravenna, to 1990; at Nelson Ledges, to 2000; while at Youngstown the auger passed through 2280 feet of the shale without reaching its base, and at East Liverpool, some miles farther south than any of the foregoing places, 2454 feet of drilling failed to pierce it.

Passing into Pennsylvania, we may state, in a word, that no borehole in the oil regions has ever reached the Corniferous limestone, so that the whole thickness of the shale is there altogether unknown. But in Crawford county, Prof. White's generalized section shows from the base of the Berea grit or the Corry and Cussewago sands, to the bottom, 1265 feet. The Cobham well, in Warren county, revealed about a thousand feet of sandy shales in the same position. The Dennis well, in MacKean county, after having found 132 feet of Pocono sandstone (the equivalent of the Berea) penetrated about 1587 feet of sandstone and sandy shales assigned to the Catskill and Chemung. In Potter county, a bore was started in the last-named stratum and was sunk through 1995 feet of sandy shales and shaly sandstone without reaching the bottom of the mass.

But all these records are distanced by that of the famous Watson well, at Titusville, the scanty details of which are apparently trustworthy so far as the main facts are concerned, though it is a matter of lasting regret to geologists that the section of this, the deepest well in that part of the state, has been irrecoverably lost. Here the auger, leaving the Pocono at the depth of 100 feet, penetrated 3433 feet of alternating hard and soft beds until the work was stopped at 2263 feet below the ocean level, in a black shale which was probably the bed immediately overlying the Corniferous limestone. It is almost certain that this stratum would have been reached in a very short distance more and the problem for that region finally solved.

Obviously the Ohio shale, excluding the Bedford, is the homologue of the great Genesee, Portage and Chemung series of New York and eastern Pennsylvania. To these may be added Catskill, which is merely a local, but immense sandy development of the upper portions of the same. The intercalation of sandy beds to the eastward and the increasing sandiness of the shale are evidence of the comparative nearness of the Devonian, and the immense increase in thickness indicates as

clearly the depression of the area between the Cincinnati anticline and the eastern shore of the Appalachian sea.*

Hypsographic Changes. No important hypsographic changes occurred during the accumulation of the lower black shale, except the continuance of the subsidence previously noted, whereby room was provided for the incoming sediment, which, in New York, is 150 feet and, in Ohio, 300 feet in thickness.

But in the succeeding subperiod—that of the middle beds or the so-called Erie shales, of Newberry—this subsidence became much more pronounced. The bottom of the gulf settled down over its whole area, so as to allow the accumulation of this enormous mass and in the east of its equivalent, the Portage and Chemung, with which there should be included the Catskill. These, in the central part of the basin, are not less than 3000 feet thick and imply slow subsidence by their many indications of shallow water. This huge mass, covering nearly 10,000 square miles of country, represents the erosive products of the latter part of the Devonian era. Its finer materials are spread out over the western, southern and central districts and the coarser deposits chiefly characterize the eastern region.

So extensive a filling implies the erosion, and therefore the elevation, of an extensive land area elsewhere. All indications point to the northeast, and especially to New England, as the region where the uplift occurred. Obviously this is only a continuation of the change above described, whereby the northeastern channel was closed in the Hamilton, or, more exactly, in the Marcellus sub-period. The limits of the area affected by this hypsographic movement it is not now possible to determine, but the bulk of the sediment is ample evidence that it was of no small extent. It probably affected, in part at least, New

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* The data for the sections given in the foregoing diagram can be found, as follows:

Findlay	*Geol. of Ohio*,		vol vi, p. ——.
Fostoria	"	"	vol. vi, p. 193.
Tiffin	"	"	vol. vi, p. 197.
Plymouth	"	"	vol. vi, p. 302.
Berea	"	"	vol. vi, p. 433.
Akron	E. W. CLAYPOLE.		
Ravenna	"	"	
Nelson Ledges	"	"	
Youngstown	*Geol. of Ohio*,		vol. vi, p. 402.
E. Liverpool	"	"	vol. vi, p. 335.
Crawford Co., Pa	*Geol. Survey of Pa.*,		Q4, p. 66.
Watson Well, Pa	"	" "	I_3, p. 154.
Cobham Well, Pa	"	" "	I_4, p. 211.
Dennis Well, Pa	"	" "	R, p. 292.
Potter Co., Pa	"	" "	G_3, p. 82.

York and even Pennsylvania, but its main effects were felt in the northeast, and it was from this region that the tributary sediments were poured into the gulf during the whole of the later portion of the Devonian era and far into that which followed it. The great estuary of New York was the inlet through which the wash of the land was brought in; here it was borne back and forth by the currents and tides until it was thoroughly sorted and sifted and deposited, according to its degree of fineness, in the catch-pit outside, where those currents were finally lost.

The estuary itself must have shared in the elevatory process and, in consequence of this, the coarser part of the earlier deposits was eroded and carried out farther and farther to sea during each succeeding period, so that a great part of the shore-history of these sub-periods was destroyed and ultimately accumulated in the later beds. This is probably the chief cause of the enormous accumulation of sand in the Catskill and subsequent periods and its comparative scarcity in the strata that represent the preceding Chemung and Portage sub-periods.

But, as the close of the Devonian era approached, there came on a great change in the condition of Appalachia. During the Corniferous and Hamilton less change occurred, the elevatory force having apparently spent itself. But now, in the time of the deposit of the upper shale, a reverse movement set in and the whole of this uplifted area was again depressed to so great an extent that it is almost certain that the Cincinnati promontory ceased to exist, and if any trace of it remained, it must have been only the two ancient islands of Nashville and Cincinnati, and a wide and open sea once more extended over Appalachia. In this sea continued the deposition of black shale which marked the later Devonian era in Ohio. In Kentucky and Tennessee it overspreads all the earlier formations with a sheet of material only fifty to one hundred feet in thickness—the Chattanooga black shale. West of the now sunken anticline it covered the Indiana slope in the same way, and is there known as the New Albany black shale; while farther west its special characters are lost and it is merged in the indivisible calcareous Devonian of the Mississippi valley.

Whether this southern subsidence reopened communication with any southern ocean it is not at present possible to determine. Nor is it absolutely certain that in some places a part of this black shale may not represent a rather earlier time. But the evidence of the fossils, so far as it exists, indicates that the shale marks the closing stages of Devonia in eastern North America.

Adopting the above stated view, the history of the period then will be on this wise. Continued elevation in the northeast produced continued erosion and removal of sediment. Continued depression in the Appalachian gulf provided room for this sediment, the coarser portions of which were dropped near the shore and in the northeastern estuary, while the finer parts were carried farther out to sea and only subsided after a voyage of several hundred miles. Accordingly, we must regard the Oneonta sandstone and the sandy and conglomerate extensions of the Chemung and the following massive Catskill as the shore and estuarine deposits in the gulf, while the black and other shales beyond the shore-sands constitute the offshore strata and grow finer and less abundant in direct proportion to their distance from land.

The proportion of sand continued and even increased after the Catskill period had come to its end. The most obvious and rational explanation of this fact is that the northeastern uplift became more rapid and the erosion therefore more severe as time passed on. One step further into the region of speculation would suggest that New England and the rest of the elevated area were formerly covered, in whole or great part, with such deposits as those which elsewhere composed the bottom of the Appalachian sea, namely: the Trenton limestone and the Utica and Hudson river shales, whose destruction supplied for a long time little besides soft material to the eroding waters. But when these had been removed and the harder underlying strata had been exposed, such as those of which the region today consists, the supply of fine material gave place to one of sand or even, at times, to pebbles, thus causing the gradual, but distinct, change so note-worthy in the strata.

Again, a singular change in the fauna lends no little support to the above interpretation of the facts. The lower Chemung has an abundant fauna which gradually disappears up-

ward, being nearly or quite extinct in the Catskill. The barren condition of the strata begins at a lower level, that is, at an earlier date in the northeast than in the southwest, indicating that conditions unfavorable to life set in sooner in the former than in the latter region, to which they gradually extended. Thus the lower Catskill beds, which are reported nearly destitute of fossils in New York, carry Chemung species mingled with their own, in middle Pennsylvania.* These facts indicate a rapid increase of erosion in the northeast owing either to a more rapid elevation or as is more probable to the greater hight attained by the land in consequence of a steady and continuous gain of elevation upon erosion.

In brief, then, the hypsometry and geography of the Devonian show a subsiding gulf receiving the wash of an elevated land to the northeast through the great estuary of New York, and thus forming the varied and assorted deposits of the Upper beds of the Devonian era.

The Catskill Sandstone.—The uppermost member of the Devonian system, as developed in the eastern part of Appalachia, is, on the principle of division here adopted, the Catskill sandstone. The geology of this remarkable stratum has provoked much discussion. A brief but excellent summary of it has been made by professor J. J. Stevenson.† He there ably argues for some of the views here adopted and attempts with no small measure of success to correlate the upper Devonian strata of Pennsylvania and New York. His general section is, as follows:

Catskill—Shales and Sandstones:
Honesdale and equivalents.
Montrose and equivalents.
Chemung—Shales and Sandstones.
Lackawaxen Conglomerate.
Shales and Sandstones.
Allegrippus Conglomerate.
Shales and Sandstones.

Nothing in professor Stevenson's paper conflicts with the view here advanced of rapid elevation in the northeast during the later portion of the Devonian era, accompanied with equal rapid and increasing erosion, in consequence of which the de-

* WHITE. *Second Geol. Surv. of Penna.*, G 7; CLAYPOLE, same series, F2.
† Chairman's address, sect. E, A. A. A. S., Indianapolis, 1891.

posits in Pennsylvania and New York of this date became more sandy and of greater mass, and were attended with an influx of fresh water, which may have been, in some degree at least, instrumental in rendering the conditions of life unfavorable to the previous marine fauna.

In any case there is little doubt that, as argued by professor Hall and others, the sandstones of the northeast, including the Oneonta, represent the shore deposits of the Upper Devonian and are not exclusively of Catskill date. Their exceeding barrenness of fossils renders proof of the proposition difficult. A few brachiopods and a single lamellibranch—*Amnigenia catskillensis*—are almost the only molluscan fossils known in the original Catskill strata. The latter species has a great vertical range. It was probably an estuarine form capable of living in both salt and fresh water or, at any rate, of enduring great variation of salinity. The fish remains that accompany it may be explained, as professor Stevenson suggests, by supposing that these rapid travellers ran up into places which the slow moving mollusks could not reach. But it is equally probable that they, too, were estuarine species and were at home in the brackish water. Unless, however, they were vegetarians, which is unlikely, their presence in strata otherwise so barren is difficult of explanation on the ground of scarcity of food.

The hypsographic changes during the Catskill period were for the most part merely continuations of those that had been inaugurated in the Chemung, with slight variations. A deep depression received the Ohio shale and Chemung deposits, 3000 feet in thickness. The area of this depression was apapparently smaller during the Catskill period than it had been previously, but more profound, inasmuch as the Catskill sandstone covers a smaller space, but is vastly greater in thickness than the earlier Chemung, etc. In some places it reaches five, six and, occasionally, seven thousand feet, implying subsidence to an equal amount. It is noteworthy that this subsidence extended up the Hudson estuary where, in the Catskill mountains, a vast thickness of this sandstone is found. But beyond that point little or no trace remains of its occurrence within the limits of Appalachia. The late Devonian subsidence then culminated in the formation of a profound catchpit, where sank the coarse sand and pebbles that the eastern and northeastern streams

brought in, while the finer detritus was carried out into the gulf and laid down as off-shore deposits.

A word should be said regarding the two conglomerates, the Allegrippus and the Lackawaxen, which figure conspicuously in the outcrops of the Chemung from Virginia to New York, but which do not appear farther to the southeast in central Pennsylvania. These assume considerable importance in consequence of the identification of the latter with the first, and of the former with the third, oil sands of Venango county, as was done by professor White. These conglomerates apparently border the northern shore of the gulf and may be the products of erosion from that quarter. But, if not, their presence need create no difficulty greater than that which is involved in the presence of the later and heavier Carboniferous conglomerates in the same region and over a wider area, whose materials nevertheless came undoubtedly from the east. The greater problem, when its solution is attained, will explain the less. Peculiar conditions whose beginnings are apparent in these Chemung conglomerates must have rendered possible the transfer of so vast a mass of pebbles along the northern margin of the Appalachian gulf, but the problem belongs rather to Carboniferous than to Devonian geology.

GLACIAL LAKE NICOLET AND THE PORTAGE BETWEEN THE FOX AND WISCONSIN RIVERS.

By Warren Upham, St. Paul, Minn.

Two years ago I spent two months of the summer in a journey east through the older states, to the Atlantic coast and New England, visiting many libraries and museums, for observations concerning the expected removal of the Minnesota Historical Society to the new state capitol.

Incidentally, opportunity was afforded for geologic examination and study of several localities that are of special interest in their relation to the great glacial lakes held by the barrier of the waning ice-sheet on the northern borders of the United States, belonging thus to a part of the Champlain epoch or closing stage of the Glacial period. Two of these studies were soon afterward published in the American Ge-

The portage and the course of the Fox river for several miles below it display indubitable features as the channel of a much larger stream formerly outflowing from the Fox basin. It is a distance of only one and a half miles from the small head stream of the Fox river, there only two or three rods wide and a foot deep at low water, to the majestic Wisconsin river, there carrying the drainage of about 8,000 square miles, equal to the state of Massachusetts.

An ascent of about ten feet is made on the old portage, passing over very flat alluvial ground from the Fox to the Wisconsin, and the descent from its upper southwestern end to the level of the large river at its ordinary stage is only five feet. During flood stages in the spring, or after heavy rains at any season, the Wisconsin here overflows its watershed, which indeed almost immediately adjoins its bank, and sends a part of its water down the Fox river. It also similarly overflows, at its times of flood, six to seven miles northwest of Portage, into Neenah creek, which runs north and east to join the Fox river after a course of about twelve miles.

Between the former sites of Fort Winnebago, close east of the Fox river, and the Indian Agency, close west of this river, at the distance of about two miles from the Wisconsin, a channel was eroded in the drift by the outflow from the glacial lake of the Fox valley to a depth of 35 to 40 feet, with a width of about 1,000 feet, along the distance of a quarter of a mile. The original surface there was about 30 feet above the Wisconsin river at Portage, and this channel could not have been due to erosion by the present Fox river, which runs through it, nor by any discharge from floods of the Wisconsin, which in this part has a range of about 10 feet from its lowest to its highest stage.

Thence the Fox river has a descent of only a few feet along its course for twenty-five miles northward. In the northern two-thirds of this distance it expands to form Menomin and Buffalo lakes, six to nine feet deep and about a half mile wide, having together a length of fifteen miles. They are thus very shallow, and are mostly filled in summer with an abundant growth of wild rice. This part of the upper Fox river evidently occupies the ancient eroded channel of a larger river which flowed in the opposite direction, being tributary to the Wisconsin valley.

Farther northeastward the Fox valley widens, and a water deposit of reddish clay overspreads the lowlands along its course. The same deposit extends also up the Wolf valley, tributary to the Fox from the north, and it likewise surrounds lake Winnebago. Its area westward from that lake was mapped approximately by Gen. G. K. Warren, who regarded this clay as the sediment of lake Winnebago when greatly extended at some former time, since the Glacial period, and outflowing past Portage to the Wisconsin river.*

More detailed examination and mapping of the old lacustrine deposit were done by Prof. T. C. Chamberlin, who found that it continues northeast to Green bay and lake Michigan, and reaches thence a long distance south, adjoining the lake shore. He writes of this red clay as follows:†

It differs most obviously from the bowlder clay, in possessing a deep reddish or purple color, which weathers at the surface to an ashy drab, while the bowlder clay, although not infrequently reddish or even purple, is usually blue or drab, and differs also in the great irregularity of its coloration. Hence the formation in question is everywhere known as the "red clay." It likewise differs from the bowlder clay in respect to the rock fragments contained in it. In the bowlder clay these are extremely abundant, and of all sizes, from mere pebbles to those of many tons weight. In the red clay, where they are not entirely absent, they are, with rare exceptions, small, seldom exceeding six inches in diameter, and more frequently they are mere hand specimens. The great majority of these fragments are of magnesian limestone, and were apparently derived from the Silurian formations prevalent in the region. . . . . Occasionally a bowlder of considerable dimensions occurs within the formation, but there is a very marked difference between this formation and the bowlder clay in that respect. This fact becomes a very conspicuous one in examining adjacent areas, occupied by the two formations. The surface of the red clay is comparatively free from bowlders, while they occur in the very greatest abundance on the surface of the bowlder clay. It may be here remarked that there is no such abundance of bowlders on the surface of the red clay district as to suggest any other origin than that of wash from the formation itself. The clay which constitutes the chief element is highly calcareous in character. It contains also a considerable portion of finely comminuted quartzose material, in addition to true aluminous clay, so that while the whole is quite compact and impervious, it yet has not that extreme toughness and adhesiveness that is possessed by the typical aluminous clays.

* Report on the Transportation Route along the Wisconsin and Fox rivers, in the State of Wisconsin, between the Mississippi river and lake Michigan, 1876, p. 88, with maps.

† *Geology of Wisconsin*, vol. ii, 1877, pp. 221-4, with maps.

A considerable ingredient of magnetite, in the form of minute grains, is present. A magnet drawn through a handful of the pulverized clay usually brings forth more or less of this mineral. Along the lake shore, where the clay is washed away by wave action, the magnetite is left as a deposit of black sand, mingled with the quartz sand of the beach, whence it may be collected in large quantities. The lower part of the deposit is usually very highly laminate, and passes, by alternations and gradations, into the subjacent beach deposit. The main mass of the formation presents little indication of the lines of deposit, but upon close inspection, minute lamination may be observed. The relation of this to the imbedded rock is interesting. As the laminæ approach the fragments, the greater portion curve downward and pass beneath it, while a portion curve over it. It would appear from this fact that the fragments were dropped upon the surface of a yielding clay mass, and covered by subsequent deposit. Near the southern extremity of this formation, it has, along the lake shore, a thickness of from 15 to 20 feet. At Whitefish bay, above Milwaukee, it is from 20 to 30 feet thick, near Ulao, 40 feet, and in the vicinity of Port Washington it reaches its maximum observed thickness of 75 feet, although it doubtless somewhat exceeds this at some points. At many places along the lake shore, owing to slides and washing, it appears to have a thickness considerably exceeding this.

It has a wide surface distribution. . . . . Commencing near Milwaukee, it widens to the north until the Kettle range is reached, by which its western boundary is deflected to the eastward until it passes that barrier and swings around upon the western side, and passing the watershed, occupies the Green Bay valley. It ascends this valley to a few miles south of Fond du Lac, and reaches up the Upper Fox river beyond Berlin, while in the Wolf river valley it extends beyond Shawano. West of the bay it appears in much less amplitude than to the southward.

From what has already been said concerning this and the underlying formations, no doubt remains that it was a subaqueous deposit. Its extent should, therefore, indicate approximately the amount of the encroachment of the lake at the time of its formation, and the altitudes to which it rises are significant of the amount of relative depression that attended its formation, and hence an especial interest attaches to its vertical distribution. At its southern extremity, it reaches an altitude of a little more than 100 feet above lake Michigan. Where its western limit crosses the north line of Ozaukee county it is about 200 feet. A few miles east of this it rises upwards of 300 feet. At the northwest corner of section 36, town of Lynden, Sheboygan county, it is 315 feet. In the town of Rhine, of the same county, the limit is found at 322 feet; at the middle of the north line of section 21, town of Memee, Manitowoc county, at 248 feet, and on the opposite side of the Kettle range, at St. Nazian, at the same height. North of this its limitation is less well defined. There are some indications that it passed entirely over the Kettle range, in the central portion of Manitowoc

county, or at least that the waters of the period did. Nowhere north of this was it observed at a height exceeding 330 feet above lake Michigan. Near Chilton it reaches an elevation of 372 feet; north of Stockbridge, 358 feet; south, 390; in section 6, Marshfield, 401 feet; in section 5, Taycheedah (T. 15, R. 23), 315 feet. These have been selected from a large number of observations, either because more reliable, or because more significant, on account of their positions. . . . . It will be observed that the formation rises gradually from its southern extremity to the region of lake Winnebago, beyond which it declines. On lake Superior an analogous clay rises at least one or two hundred feet higher.

Aside from the general northward depression indicated by these facts, a special flexure seems to have taken place in the region of lake Winnebago, either of the nature of a greater depression during the time of deposit, or of a greater elevation subsequently. This fact is entirely in harmony with the concurrent indications of several peculiar features in the underlying formations and general structure of the region. It is on the basis of this general northward depression, and on the sequence of the formations, that this and the associated deposits are referred to the Champlain period.

When Warren and Chamberlin thus described the region of the Fox river, lake Winnebago, and Green bay, the effect of the barrier of the waning continental ice-sheet to form lakes in basins sloping northerly toward the receding ice border had not been fully and generally recognized. Neither of these writers appealed to the glacial barrier on the north as the cause of the formerly greater lakes which they mapped and described; nor did Chamberlin refer to the southward outlet at Portage, near the head of the Fox valley, but rather ascribed this entire lacustrine tract to an expansion of lake Michigan when the lake Winnebago region was much depressed below its present altitude.

Portage and the Fox river basin were covered by the Green Bay lobe of the ice-sheet during its moraine-forming Wisconsin stage, and the recession of the western side of this ice lobe probably began somewhat earlier, and uncovered the formerly ice-enveloped country somewhat faster, than the concurrent recession of the southern part of the Lake Michigan ice lobe, which lay upon the area of the glacial lake Chicago. The two outlets, however, at Portage and at Chicago, doubtless began to discharge the waters of glacier-dammed lakes on the north and northeast at nearly the same time; and each of these lakes existed independently of each other until the continued glacial

recession of both the Green Bay and Lake Michigan lobes permitted the lakes to meet and merge somewhere northeast of lake Winnebago, then assuming the same level and a single outlet. Up to that time there were two glacial lakes, and for that in the Fox basin I will propose the name *Lake Nicolet*, in commemoration of Jean Nicolet, the earliest explorer of this region. Like the glacial lake Duluth, so called by Taylor for the city of Duluth, this ancient lake outflowing at Portage will bear the name of a grand pioneer of European civilization who came there and brought to Canada and France a knowledge of its area and its aboriginal tribes.

Jean [John] Nicolet is supposed to have been born in or near Cherbourg, France, probably in 1598. He came to Canada in 1618, and during twenty-four years was a most energetic and honored agent of the proprietors of Canada for the promotion of the fur trade. In the autumn of 1634 he visited the Sault St. Marie, and thence came to Green bay, being, as was before noted, the first white man known to have visited any part of Wisconsin. He died on one of the last days of October, 1642, drowned by shipwreck on the St. Lawrence river near Quebec. This early explorer is to be distinguished from the geographer and scientist, Joseph Nicolas Nicollet, who two centuries later explored the area of Minnesota and the Dakotas.*

Portage, the county seat and chief town of Columbia county, is built on the eastern side of the Wisconsin river where it was joined by the old portage course from the Fox valley. The northwestern and principal part of the town is 30 to 50 feet above the river, but its southeastern part is on the low alluvial tract of the portage, subject to occasional overflow by the river floods, which thence run north and are tributary to lake Michigan. For a mile through the town its upper part is terminated against the lowland by an eroded bank or low bluff, cut by the outlet of the glacial lake Nicolet. On the lowland, near the foot of the bluff, a canal connects the Wisconsin

* History of the Discovery of the Northwest by JOHN NICOLLET in 1634, with a sketch of his life, by C. W. BUTTERFIELD. (Pages 113; Cincinnati, 1881). His surname was sometimes spelled Nicollet.

See also a biography of the later Nicollet, by PROF. N. H WINCHELL, in the AMERICAN GEOLOGIST, vol. viii, pp. 343-352, with portrait, Dec., 1891; and "Additional Facts about Nicollet," by HORACE V. WINCHELL, *ibid.*, vol. xiii, pp. 126-128, Feb., 1894, giving short biographic sketches of both these explorers, and correcting a prevalent error concerning the Christian names of Joseph Nicholas, before called "Jean N."

river with the Fox, which, by canal locks and dredging, has been made navigable to lake Winnebago for small freight boats and excursion steamers.

The following series of altitudes, referred to the sea level, show the relation of the former lake Nicolet to the present lakes Michigan and Winnebago and to the Fox, Wisconsin, and Mississippi rivers.

Lake Michigan, low and high stages, 578-584; mean stage	581
Upper limit of the red clay, deposited in lakes Chicago and Nicolet:	
Near Milwaukee, about	690
30 miles northward, on the north line of Ozaukee county, about	780
In Sheboygan county, 5 to 25 miles farther north	890-900
A half mile west of the center of Memee township, in the south part of Manitowoc county	829
At St. Nazian, also	829
Near Chilton, east of lake Winnebago	953
South of Stockbridge, near the middle of the east shore of this lake	971
North of Stockbridge, a few miles from the last	939
In section 6, Marshfield, Fond du Lac county	982
In section 5, Taycheedah, near Fond du Lac	896
Lake Winnebago	748
Buffalo lake, Fox river	778
Summit level of the canal	788-790
Wisconsin river at Portage, feeding the canal, and separated from it by a guard lock, low and high stages	787-796
Mississippi river at the mouth of the Wisconsin, 118 miles distant from Portage by the course of that river, low and high stages	604-626

The alluvial deposit of the overflows from the Wisconsin river has filled the old bed of the outlet of lake Nicolet to the depth of probably 10 feet or more at Portage and northward. The original channel bed, therefore, at the mouth of the glacial lake, has now an altitude, beneath the alluvium, of about 780 feet above the sea. It is thus 190 feet higher than the rock floor of the outlet from the glacial lake Chicago, about 150 miles distant to the southeast; and it is 290 feet lower than the swamp divide in the channel eroded at the head of the St. Croix river by the outflow from the glacial lake Duluth, about 225 miles northwest of Portage.

From my detailed examinations of the glacial lakes Souris, Agassiz, and Duluth, it seems to me quite certain that the red

clay described by Chamberlin, as before quoted, is not an ordinary lacustrine sediment, in the sense of being brought by tributary streams or supplied through erosion from the shores and bed of the old lake by its wave action, but rather that this deposit consists of englacial drift which here was received into the water of the glacial lake. By lacustrine action it was somewhat stratified and assorted, but, by its inclusion of frequent rock fragments, it yet retains generally, as I think, more of the features of till than it has acquired of the usual characters of water-laid drift.

The purpose of this paper does not include a discussion of the relation of lake Nicolet to lakes Chicago and Duluth, which can only be learned by much field work, with exact mapping of the old shore lines and determination of their hights by leveling. It seems sufficient here to add that, if lake Chicago at any time fell below the Chicago outlet, it must, in my opinion, have then outflowed by the way of Portage to the Wisconsin river.

An exceptional uplift of the region about Portage, the upper Fox river, and lake Winnebago, exceeding that of the surrounding country, may well have taken place between the times of formation of the first and second of the lake Chicago beaches, giving to this area of lake Nicolet the altitude which it has since held, or perhaps slightly more. Indeed, the uplift seems to have been followed by some depression there, or at least about Green bay, while the country northward, including the basin of lake Superior, was being elevated.

The complex and very interesting history of the departure of the ice-sheet from the St. Lawrence basin, the sequence and changes of its immense ice-dammed lakes, and the variable northward uplift of the country during that geologically short Champlain epoch, continuing in less degree to the present time, I somewhat fully reviewed about eight years ago.* The opinion then expressed seems to me still to be true, that, after lake Chicago (since that time so named by Leverett) and lake Duluth (since named by Taylor) became confluent, their successor, lake Warren (named and well described before that

* *Amer. Jour. Sci.*, third series, vol. xlix, pp. 1-18, with map, Jan., 1895; Twenty-third Annual Report, Minnesota Geol and Nat. Hist. Survey, for 1894 (pub. 1895), pp. 156-193, with map. This paper contains very full bibliographic citations of all previous writers on the glacial lakes of the St. Lawrence basin.

time by Spencer) occupied the basins of all the great lakes now tributary to the St. Lawrence, excepting that of lake Ontario, with outflow past Chicago in the same course as the previous smaller lake Chicago, and with only slightly deeper erosion of that outlet, then forming the third and lowest of its beaches about the end of lake Michigan.

ON SOME RECENT LITERATURE BEARING ON THE LARAMIE FORMATION.*

By O. P. HAY.

The first two papers of those whose titles are here recorded have provoked the utterance of most of the others; and of the two, the first is a summing up of the results and conclusions to be derived from the second, the largest and most elaborate on the list.

Mr. Lambe, a member of the Geological Survey of Canada, had during the years 1897, 1898, and 1901, made large collections of fossil bones from the deposits known as Belly River series. The localities especially explored by him lie along the Red Deer river, in the Province of Alberta. A study of his collections has resulted in the important publication cited above. The species which he has described and abundantly figured consist principally of reptiles, but there are in addition five fishes, one batrachian, and two mammals. Two fishes, twelve reptiles, and two mammals are described as new. Seventeen forms are identified with species already described. For the reception of new species four new genera are established. Mr. Lambe is to be congratulated on the workmanlike manner in which he has studied and presented this fauna. It is evident that the Cretaceous deposits north of the 49th parallel are rich

*1. Distinctive characters of the Mid-Cretaceous fauna. OSBORN, H. F., Contrib. to *Canadian Palæont.*, iii, 1902, pp. 7-21.
2. New genera and species [of Vertebrata] from the Belly river series (Mid-Cretaceous). LAMBE, L. M., Contrib. to *Canadian Palæont.*, iii, 1902, pp. 25-81, with pls. i-xxi and 24 text figures.
3. New Vertebrates of the Mid-Cretaceous. OSBORN, H. F., *Science*, xvi, 1902, pp. 673-676.
4. A correction of Professor Osborn's note entitled "New Vertebrates of the Mid-Cretaceous." HATCHER, J. B., *Science*, xvi, 1902, pp. 831.
5. The Laramie Cretaceous of Wyoming. WILLISTON, S. W., *Science*, xvi, 1902, pp. 952-953.
6. The stratigraphic position of the Judith river beds. A correction of Mr. Hatcher's correction. STANTON, T. W., *Science*, xvii, 1902, pp. 1031-1032.
7. Age of the typical Judith river beds. OSBORN, H. F., *Science*, xvii, 1903, pp 356-357.
8. The Judith river beds. HATCHER, J. B., *Science*, xvii, 1903, pp. 471-472.

in the remains of vertebrates, and we may expect to hear much from him hereafter.

Mr. Lambe naturally accepts the determinations made by the members of the Geological Survey of Canada regarding the age of the Belly River beds. Dr. G. M. Dawson, Mr. R. G. McConnell, and Mr. J. B. Tyrell have agreed that these beds lie below the Montana group, which includes the Pierre and Fox Hills deposits. The various strata which have been known to the geologists of the United States as the Laramie have almost universally been regarded as overlying the Montana. Since one-half of the species of vertebrates described by Mr. Lambe are regarded by him as identical with Laramie species and most of the remainder are somewhat closely related, a conflict of opinion has arisen. Two questions are propounded: (1) Is there not an error in the determination of the position and age of the Belly River beds? (2) Do not some of the deposits of the so-called Laramie of the United States occupy a lower horizon than has hitherto been supposed, a horizon equivalent to that of the Belly River beds?

Professor Osborn, in his first paper discusses the geological relations of the fauna as represented in Mr. Lambe's paper, the faunal characters, and the general relations of the fauna. His conclusions, as summed up on page 21, are to the effect that the Belly River fauna is more ancient in character than that found in the Laramie, that the interval represented by the Pierre-Fox Hills marine beds was accompanied by the extinction of certain Jurassic types and progressive evolution of the persistent types, and finally that probably some of the fossil vertebrates described from Montana are of Belly River age.

Hatcher in his latest communication holds that it is premature to assert that the true Judith River beds, from which so many of the supposed Laramie species of vertebrates have been described, certainly overlie the Montana formation.

Williston expresses himself as skeptical regarding the position of the Laramie beds of Converse county, Wyoming, above the Fox Hills beds.

Stanton declares himself emphatically of the opinion that the Judith River beds overlie the Pierre beds and are of more recent age.

An observation may be permitted regarding the table presented by Professor Osborn on pages 11-15 of his first paper. He has, in showing the distribution of the fossil vertebrates concerned, given one column with the heading "Judith River" and another with the heading "Montana." To the writer it appears that nearly all the species which are checked off as occurring in Montana ought to appear in the Judith River column and this fact was recognized by professor Osborn himself (p. 10.) The ones to be excepted are *Mylognathus priscus,* from Long lake, N. Dakota, and *Trionyx vagans* and *Compsemys lineolatus,* reported from the Big Horn river. All the rest are certainly from the Judith River basin, unless again we except *Manospondylus* and *Claorhynchus,* whose localities are not given. Those from the Judith River basin must be regarded as from the Judith River beds until some one has shown that more than one formation has been included. The above corrections being made, we find that the great majority of Laramie vertebrates have been described from the Judith River beds, and that the comparison of the Belly River fauna must be made especially with these Judith River species.

What the meaning of the resemblances and differences between the Belly River and Laramie faunas may be will not be understood until the stratigraphical relationship of their respective deposits has been finally determined. "Non palæontologia sine geologia." Nevertheless, it seems that some of our writers have unnecessarily permitted their faith in the determinations of the stratigraphers and palæontologists of the United States to be shaken by the conclusions of their Canadian brethren. While all our opinions and theories must be held subject to revision, perhaps to reversal, it appears to the writer that the position of the Judith River beds of Montana and the Ceratops beds of Wyoming above the Montana formation has been abundantly demonstrated. Our geologists and palæontologists have studied the geology of the plains and Rocky Mountain region for nearly fifty years, and there is no satisfactory evidence that a fauna resembling that of the Laramie occurs anywhere beneath the Montana formation. The Judith River region in particular has been visited by Hayden, Meek, Cope, Stanton, and Weed; and these agree in affirming that the Judith River beds are underlain by Fox Hills

deposits, as Stanton has pointed out. Hatcher has, indeed, told us that in his work in that region he saw no Pierre deposits beneath the Judith River beds, but did see deposits resembling the Pierre overlying the Judith beds. It will, however, not be insisted that this statement shakes the positive observations of many other geologits.

Dr. Williston has done us a service in identifying a number of species from the Ceratops beds of Wyoming. All will agree with him that there is a striking resemblance between this fauna and that of the Belly River beds; but it is certainly quite as probable that the Canadian geologists have been mistaken as that those south of parallel forty-nine have all fallen into error. And what avails it to depress the Judith River and Ceratops beds into contemporaneity with the Fox Hills, while the Belly River beds repose beneath the Pierre? At best, the interval between the two formations is diminished only a little.

In the present state of our knowledge, it would be both unfair and unprofitable to dispute the conclusions of the Canadian geologists. Nevertheless, that region in British America ought to be reinvestigated. Only when the stratigraphy has compelled us to do so can we believe that a fauna, so large and varied, has continued with comparatively little modification through the period of two or three distinct formations.

As to the invertebrate portion of this fauna, Whiteaves declares (Cont. Canad. Palæont., i, 1885, pp. 55, 89) that it would seem impracticable to separate by means of it the Belly River deposits from the Laramie. He also remarks in this connection that Dr. Dawson's "Lower Dark Shales," found beneath the Belly River beds can scarcely be separated on palæontological grounds from the Pierre. Is it possible that the Pierre beds too are duplicated in that region?

As regards the vertebrates; of Mr. Lambe's 33 species, 15 are identified as species already described by Cope and Leidy from the Judith basin; one, Baëna hatcheri, had been reported from Converse county, Wyoming. From the latter locality, Dr. Williston reports 6 or 7 more of the Belly River species.

Of Mr. Lambe's species which have not yet been found elsewhere, 7 belong to genera which have been found in the Judith beds; and none of these, except Trachodon, is known to endure through more than a single period. Furthermore, of the

Belly River species three, Trionyx vagans, Adocus lineolatus, and Bottosaurus perrugosus, were described from northeastern Colorado, from probably the Arapahoe beds, which Whitman Cross places above the typical Laramie. Again, Mr. Lamb's mammal, Ptilodus primævus, belongs to a genus which is otherwise known only from the Torrejon Eocene. Indeed, if we exclude all genera known only from Belly River and Laramie deposits, we shall find that not more than three are represented by species older than the Pierre, while no fewer than eight are known from the Tertiary.

As bearing on this question may be mentioned some materials which were collected by Mr. Barnum Brown, in 1902, for the American Museum of Natural History. On Hell creek, twelve miles north of the Missouri river, and 130 miles northwest of Miles City, Montana, there were found remains which are identified as follows:

Lepisosteus occidentalis (Leidy).	Champsosaurus 2 sp.
	Crocodylus humilis.
Compsemys victus (Leidy).	Ornithominus sp.
Adocus lineolatus (Cope).	Monoclonius sp.
Basilemys variolosus (Cope).	Triceratops sp.
Trionyx vagans (Cope).)	Deinodon mirandus (Marsh).
T. foveatus (Leidy).	Dryptosaurus sp.
Plastomenus costatus (Cope).	

This list resembles much, so far as it goes, the one published by Mr. Lambe; and yet the materials were found between one and two hundred feet above the Pierre deposits (as indicated by the invertebrates identified by professor R. P. Whitfield), and most of the others above a fine skull of Triceratops.

The writer may be permitted to make an additional remark on professor Osborn's first paper. On page 18 this author states that the present writer is of the opinion that Cope was justified in rejecting the name Deinodon. This is an error. What the writer holds is that Cope was justified in *restricting* the name Deinodon, limiting it to those teeth originally described under the name Deinodon horridus which have a D-shaped section. If these teeth belong to a different genus from those with opposite cutting edges, as Cope, Leidy, and Marsh all have believed, then the binding force of Cope's action cannot

be questioned. If the teeth of both kinds belong to the same genus, there is no need of Leidy's name Aublysodon; which proposition is equally true in the other case. Marsh has set aside, as types of Aublysodon mirandus, the teeth represented by figures 41-45 of plate ix, of Leidy's paper in volume XI of the Transactions of the American Philosophical Society, 1860. Mr. Lambe has figured a similar tooth and referred it provisionally to Ornithomimus. If this shall prove correct, the species must be known as Ornithomimus mirandus. A criticism or two may be made on Mr. Lambe's nomenclature. He has referred some scales of a fish to Lepidotus Leidy. Similar scales have been found by Dr. Williston which were accompanied by the peculiar vertebræ of Lepisosteus; and in looking over some Judith river materials collected by Sternberg for Cope, I find similar vertebræ. This makes it probable that the scales from the Belly River beds belong to Lepisosteus. Mr. Lambe has identified some cranial bones of fish with Cope's Ceratodus eruciferus, but has placed them in the genus Rhineastus, a Bridger genus of Siluroids. It is doubtful whether Cope's type belongs to Ceratodus, but it is quite as unlikely that it belongs to Rhineastes. Mr. Lambe has provisionally associated with these bones some fragmentary spines. In Mr. Brown's collection referred to above there is a nearly complete spine which resembles those found by Mr. Lambe, and this certainly does not belong to Rhineastes; since it is not serrated behind and does not form the peculiar articulation with the interneural that is found in Rhineastes.

In these discussions it must be kept in mind that the identifications of species may not always be correct. The materials found are likely to be fragmentary; and whether so or not, they must often be compared with fragmentary types. The path of the vertebrate palæontologist is beset with many pitfalls.

Of the papers of professor Osborn and Mr. Lambe especially it may be said that they have awakened an interest that will not subside until some important questions have been decided. If the Belly River beds have the position that is claimed for them, Mr. Lambe has the satisfaction of knowing that he has brought to light the very oldest known forms of several genera.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Geography of Minnesota. By CHRISTOPHER WEBBER HALL. Pages xii,. 299; with 6 plates, and 163 figures in the text. Minneapolis. The H. W. Wilson Company, 1903.

This little book seems well adapted for use in Minnesota schools and colleges, whether for recitations or as supplementary reading. It is written in a simple style, and has abundant illustrations from photographs, with numerous maps, profiles, and sections, which must interest school children, and also older people, in the physical features of the state, and the causes that produced them.

In thirty-six chapters, the contour of Minnesota, its weather conditions, former glaciation, natural water supplies, common and artesian wells, stream erosion, the present lakes and ancient glacial lakes, prairies, forests, hills and mountains, minerals and rocks, are concisely described and pictured. Many of the pictures are from the geological, botanical, and zoological surveys of this state.

Another volume, on a similar plan, seems to be promised, as this book is called Volume I of "Geography and Geology of Minnesota." The present work treats only incidentally of the geology as explanatory of the geography, but thus deals somewhat fully with the glacial and modified drift, and with the sculpturing of the older rocks to their present topographic relief. W. U.

Geology and Water Resources of the Snake River Plains of Idaho. By ISRAEL C. RUSSELL. Bulletin of the U. S. Geol. Survey, No. 199. Pages 192; with 25 plates, and 6 figures in the text. Washington, 1902.

The area here described consists mainly of lava, extending across southern Idaho, with a length of about 350 miles, and a width of 50 to 75 miles. Its western part is about 3,000 feet above the sea, and it rises on an average about 10 feet per mile eastward. The Snake river, or Lewis fork of the Columbia, in flowing through this area, has vast water power, with numerous cataracts, of which the Twin falls, 180 feet high, and Shoshone falls, 210 feet high, are the grandest. The dryness of the climate forbids agriculture excepting by irrigation, and the plains are chiefly utilized for stock raising. On each side rise rugged, sharply serrate mountains, varying from a few hundred feet to more than 6000 feet above the plains. The mountains, so far as known are of Paleozoic or older rocks, and are considered to have been uplifted mainly before the Mesozoic era, and to have been deeply eroded before the beginning of the Tertiary.

On the site of this great valley plain or basin, now traversed by the Snake river, a lake existed during the Miocene period, whose sediments named the Payette formation, "are mainly sands, clays, and vol-

canic lapilli, with occasional beds of coarse gravel, especially near the bases of the bordering mountains." The thickness of the Payette lake deposits, according to Lindgren, exceeds 1,000 feet in the vicinity of Boisé, the capital of Idaho. Later, in the Pliocene period, while the principal lava eruptions were taking place, a smaller lake, the immediate successor of lake Payette, remained in the southwest part of the state, called lake Idaho by Cope.

Basaltic lava flows cover an area of about 20,000 square miles in this basin, having thus about a tenth as great extent as the vast lava field cut through by the Columbia river. In the Snake river canyon, below Shoshone falls, nearly 700 feet of lava in horizontal sheets are exposed, but its aggregate total thickness has not been determined. Generally the various sheets of the lava, representing successive eruptions, are "relatively thin, averaging perhaps 50 to 80 feet, and widely extended."

Sir Archibald Geikie, when traveling in this country in 1879, after seeing these Snake river plains of lava, attributed them to fissure eruptions. This view, however, is not favored by Russell, who in this report presents a very convincing account of his observations, showing that the lava issued from many small craters on the basin plain and in the lateral valleys of the inclosing mountains. The eruptions began probably in Miocene times, and continued, interruptedly, until only a few centuries ago.

Professor Russell concludes that the surface water supply is capable of two or three times its present utilization; that the entire summer flow of all the streams reaching these arid plains can be employed for irrigation; that storage reservoirs should be constructed; that test wells should be drilled to pass through the lava beds, into the underlying fluvial and lacustrine sands and clays, in the hope of obtaining artesian water; and that the control of the water supplies, both for irrigation and domestic uses, should be under the direction of a competent engineer. W. U.

Studien uber das Nordbaltische Silurgebiet, I. von CARL WIMAN [Bull. Geol. Instit. of Upsala, No. II, Vol. VI, Part I, 1902.]

This first study (on the Cambrian) is based on the remains found in the Olenellus sandstone, the Obolus sandstone and the Ceratopyge shale.

A full account of the literature of the subject is given, even back to the time of Laurentius Roberg (1715) and onward from then.

The mode of occurrence of the rocks is given—first, in the original ledges, then as loose blocks, then as they are found in the morains, then the occurrences in the gravel ridges or åses ("osars"), then as they are found in the glacial clay, and finally as rolled fragments on the shore of the Baltic sea. The treatment is thus very full.

The Olenellus sandstone shows various phases; a predominant one is a bituminous sandstone; many fragments are conglomeritic and hold concretions of phosphate of lime. A good many fossils have been found

in this rock. Another form of the Olenellus sandstone is a glauconite bearing sandstone which has yielded a few species of fossils in abundance. Other forms of the rock are rusty sandstone, gray quartzose sandstone, variegated sandstone and a bluish calcareous sandstone.

Olenellus stands at the front among these fossils for number but the pieces are fragmentary, and so the species could not be determined. A doubtful fragment of a Paradoxides was found, but the determination to this genus is quite uncertain, and it is associated with an Arionellus and an Ellipsocephalus which are of a type similar to those found below the Paradoxides beds.

NOTES ON THE FAUNA.

Herr Wiman's excellent figures give a very good presentation of this fauna of fragments from the Drift, etc., of northern Sweden and afford some interesting comparisons with those of North America. Some of the most widely distributed fossils are fragments of Olenellus; out of two score of occurrences of this trilibite only fifteen fragments are figured and these badly broken; the genus is recognized by its sculpture. The Arionellus is of the sub-genius Strenuella which occurs in the Upper Etcheminian fauna of Newfoundland. The Ellipsocephalus may be compared with *E. galeatus* Matt. of the Protolenus fauna. Hipponicharion and Beyrichona characterize the same fauna.

The shells referred to Acrotreta show their antiquity by the depressed umbo, as well as by the convex anterior slope of the ventral valve of one species. The internal markings are not shown so one does not know whether they belong to Acrotreta, or Acrothyra, but the form of the shells conforms to that of the Acrothyræ of the Lower Etcheminian fauna.

Lingula bottnica is referred to the genus Lingula on account of the resemblance in the sculpture of the interior of the ventral valve to that of *L. anatina* Brug and *L. palmeri* Dav.; the species may also be compared, as regards its high cardinal area, its general form, and the markings of the ventral valve to *Lingulepis longinervis* Matt. of the Lower Etcheminian fauna.

A remarkable fossil is that described as *Causia formosa* n. gen. et spec. To judge from the position it holds in the classification of the species, it would seem that it was recognized as a Neotrematous Brachiopod; it looks like a gigantic Acrothele. The ventral valve, the only one figured, is nearly 5 cm. across and 2 cm. high; the front slope is hollow as is often the case in Acrothele, but the apex is broken away.

A slender curved conical shell has been described as *Stenotheca cornu* by Dr. Wiman, which reminds one of the various ways in which this generic term is used. It was originally applied by Salter to a quite small, thin-shelled, folded univalve or bivalve crustacean, thence it was used for a conical calcareous gasteropod, similar in form when viewed from the side to the original Stenotheca, and later extended to more elongated conical shells. Dr. Wiman's use is similar to this last, but he states that the shell is chitinous.

The whole aspect of this fauna is pre-Paradoxidean and one wonders what has become of the rich Paradoxides beds of southern Sweden in this northern area. A similar hiatus is found in the Cambrian beds of the eastern side of the Baltic, and it would seem that there must have been a break with elevation of the sea bottom, causing the absence of these middle measures in this northern part of Scandinavia. Dr. Wiman appears to take this ground in his classification of the Cambrian-Silurian succession at page 24.

These drift fragments have also yielded a series of fossils of Upper Cambrian type, figured on the third plate of fossils. Among the trilobites the three genera Acerocare, Shumardia and Ceratopnyge are recognized. All these fossils are referred to the Ceratopyge region by Dr. Wiman, to which region he appends the Obolus sandstone as an under member. On Plate III are figured a number of examples of *Obolus Apollonis* which show the strong muscular markings that characterize that species. Two conodonts also are figured showing the presence of certain marine worms as low down as the Ceratopyge beds.

This article is another contribution to the excellent palæontological work done by Dr. Wiman. G. F. M.

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CORRESPONDENCE.

In the GEOLOGIST for May, p. 312, under the caption "HOW LONG AGO WAS AMERICA PEOPLED," professor Upham expresses the following views:

"Any estimate of the antiquity of man * * * * must depend on the measures or estimates obtained by geologists for the duration of the Post-glacial period, and of the much longer glacial period.

"For the time since the end of the Ice age, apparently nearly alike in America and Europe, approximate determinations have been given by N. H. Winchell, G. F. Wright and many other glacialists, as summarized by Hansen, which range from 5000 to 12,000 years. *Their average, or about 8000 years, may be confidently accepted as near the truth.*"*

To the acceptance of the italicized portion of the above quotation, the undersigned desires to express an objection. The basis of this objection is outlined below.

1st. The floods of ice which overspread the land areas of the northern hemisphere, were apparently synchronously imposed and extended at least to Lat. 28° to 40° N. reaching their maximum depths about 50° N., from which latitude they flowed both northerly and southerly, but more actively in this latter direction, due apparently to their having been melted from this side.

2nd. The retreat has unquestionably been by stages which have been given suitable names, generally geographic; these stages of retreat may have been interrupted by periods of advance.

3rd. These periods of retreat, or stages, have been distinctly progressive in the northern hemisphere from more southerly latitudes towards the north. No estimate of the period since the retreat of glacial conditions from Lat. 28° N., in the Mississippi valley has been

* Italicized by the present writer.

made, which would place that retreat within 12,000 years—nor would so long a period be assigned to the retreat from the upper part of this valley, in Lat. 48° N. Again, 5000 years would be far too long a period to assign as the length of post-glacial time in large areas in British Columbia, whilst in Alaska, it is manifest that the glaciers of the St. Elias group covered areas notably greater when America was discovered, than they cover now. It is evident also, that in spite of short periods of temporary advance, the glaciers of the northern hemisphere are yet gradually retreating, and that the Ice age has not yet departed from that hemisphere.

It is manifestly not logical nor correct, to take ***an average*** of the various estimates of the length of post-glacial time at these various latitudes as representing anything except the time at which glacial retreat may have passed an ***average latitude,*** somewhere between the extreme ranges of the stages taken into consideration. This average time period could not be the time which has elapsed since the Kansan stage, any more than it could be that which has elapsed since the "Sitkan" stage, in which region active retreat is yet in progress. But the average between an estimate of post-glacial time since the Kansan stage and the present, would give a period applicable to some latitude between 38° N., and 58° N.

The average of all fairly reliable estimates of the length of post-glacial time at various latitudes, is applicable not to the time since the end of an age not yet passed, but to the time since the line of retreat passed some intermediate region between the extreme stages. If several geologists made separate and different estimates of the time since the Kansan stage, an average of these estimates might be nearer the truth than either of the extremes. But such average could not properly be applied to the length of time which has elapsed since glacial ice receded from the site of Yankton, S. D., or from the Canadian rockies.

To give a still farther range to the progressiveness of glacial retreat, the undersigned cites the evidences of ice action in lower California, in Lat. 23° to 24° N.; around Puget sound in Lat. 48° to 50° N., and at the head of Lynn canal, in Lat. 59° N. The retreat of glacial conditions from the peninsula of Lower California may have been 50,000 or more years ago; from the Puget Sound region, 10,000; and from the head of Lynn canal, 1500. The average of these periods, assuming them to be approximately correct, is 30.750 years, which may represent the lapse of time since some of the Sierra glaciers extended to the base of that range.—But it certainly does not represent the probable length of time since the Ice age. Glacial conditions which existed at the culmination of that age, have been, and are yet being progressively removed, and this removal has recorded and is recording its progressiveness in both hemispheres toward polar regions and from sea level upward.

The rate of retreat is unquestionably slower as the limit is approached—but at all latitudes and altitudes at which glacial ice yet rests, this retreat, although slightly fluctuating, is yet in progress.

The ultimate limits have therefore not yet been reached, nor has the Ice age entirely departed from the earth. MARSDEN MANSON.
San Francisco, Cal., June 24, 1903.

COLUMBIAN UNIVERSITY GEOLOGICAL DEPARTMENT. The eastern branch of the summer field work in geology was conducted this year at Larrabee's point, Vermont, during the first week in June. Thirty students were present. The work was under the guidance of professor J. F. Kemp and professor A. W. Grabau, assisted by Mr. H. W. Shimer. The Ticonderoga sheet of the U. S. G. S. was used as a basis of work. This section was chosen because it united so well excellent stratigraphic, structural, physiographic and glacial features; and a range of rocks extending from the Archæan through the Utica.

The Archæan and Algonkian rocks are very well developed on the western side of lake Champlain, as are also many igneous rocks of doubtful age. One of the most noticeable of the Algonkian beds is a very coarsely crystalline marble occurring in scattered areas over most of the western half of the sheet. This area was evidently above the sea during the Lower and Middle Cambrian time for the Potsdam was deposited upon its flanks in a sea encroaching from the east. But we find in the southeastern portion of the sheet, west of Choate pond and adjoining sections, Greenwich slates which Dale has correlated with the Georgian (Lower Cambrian). We, however, could find no definite traces of fossils as the cleavage runs at a high angle across the bedding. The Potsdam is usually a dense, gray quartzyte, becoming in places slightly conglomerate as it approaches the old land.

The Ordovician series rests conformably upon the Cambrian except where by faulting or folding its original relations have been disturbed, as northeast of Sisson hill and in many other places, for the entire region is much faulted. The lowest of the Ordovician series, the Beekmantown, is over this area very thick, reaching perhaps a maximum of eighteen hundred feet. The lowest part of this bed has many quartzyte layers identified in appearance with those of the Potsdam but separated from the latter by calcareous beds; hence the Beekmantown, an areno-calcareous formation, and which represents the transition from the pure arenaceous beds of the Potsdam to the pure calcareous beds of the chazy shows here an alteration of Potsdam and Beekmantown conditions. Most of the Beekmantown is unfossiliferous, but some of the middle and upper beds are very full of fossils. There are several species of Ophileta, including *O. complanata;* also several species of trilobites. Most of the Beekmantown is rather heavy-bedded but in some places it is quite shaly.

Upon the Beekmantown rests the chazy, a dark, heavy-bedded limestone forty to fifty feet thick. This contains many fossils, the most characteristic of which is *Maclurea magna.* The rock also contains very many Orthoceras and Cystoceras shells.

The next higher formation here is the Trenton, a limestone varying in thickness from one hundred and fifty to two hundred feet. The Lowville and Black river were not here determined; but their time-

equivalents are perhaps the upper chazy and lower Trenton. These Trenton beds are exceedingly fossiliferous, the rock being in many places one mass of fossils. The most characteristic and abundant coral is *Monticulipora lycoperdon.* The brachiopods are best represented by *Parastrophia hemiplicata, Phynchotrema copox, Rafinesquina alternata, Plectambonites sericeus* and *Strophomena rugosa (planumbonum).* Among trilobites the most characteristic are *Trinucleus concentricus, Isoteles (Asaphus) gigas* and *Calymene senaria.* The Trenton outcrops are especially fossiliferous both north and south from Larrabee's point along the lake shore.

The Utica shales, the highest palæozoic strata here remaining, rest conformably upon the Trenton. In most places they are devoid of fossils as they are highly cleaved across the bedding; but on the lake shore about a half mile south of Larrabee's point in a cut made by the Rutland railroad the cleavage is not so marked. Here many specimens of *Diplograptus pristis* were found as well as one specimen each of *Endoceras proteiforme* and *Triarthrus bechii.*

Wherever the surface, especially of the harder rocks, is exposed they are found to be glaciated. Upon this glaciated surface were deposited the Champlain clays during the post-glacial subsidence. The basal beds contain very many concretions, in which, however, no fossils were found included, although much time was spent in looking for them. These beds and the later deposits still cover the valleys and plains, especially in the western half of the sheet, thus covering the palæozoic outcrops.

The entire region is very much faulted. One fault, for example, extends from the swamp north of Sisson hill through the valley east of the hill, southward past the western edge of Barnum hill. West of the fault is Utica shale; east of it at Sisson hill is Beekmantown, at Barnum hill the basal Beekmantown. The faults not only extend north and south but also east and west and indeed in almost every direction.

HERVEY W. SHIMER.

PERSONAL AND SCIENTIFIC NEWS.

WARREN UPHAM DURING LAST MONTH visited the Puget Sound region, for observations of its glacial and modified drift, and for a special study of the geology of Snoqualmie falls, 270 feet high, from which electric power is transmitted to Seattle and Tacoma.

MR. E. O. HOVEY OF THE AM. MUS. NAT. HIS. has recently returned from a second visit to the West Indies where he spent three months visiting the volcanoes of St. Vincent and Martinique and extending his studies to the other volcanoes of the Lesser Antilles from Saba to St. Vincent.

DR. C. R. EASTMAN OF HARVARD, who has been spending his sabbatical abroad engaged in special palæontological re-

search, has returned to Europe in company with Dr. Holland, director of the Carnegie Museum, to take up the study of the fossil fishes in the famous Bayet Collection, recently acquired by the Pittsburgh institution.

THE DEPARTMENT OF BOTANY AND GEOLOGY in the University of Minnesota are this year represented at the Minnesota Seaside Station, near Port Renfrew on the southwest coast of Vancouver island, by professor Conway MacMillan and professor C. W. Hall. With a large party of students, they left Minneapolis on July 14th, and expect to return August 26th, by the route of the Canadian Pacific Railroad. Four weeks will be spent in field and shore collecting and the laboratory work at the station, now occupied for its third year.

MR. CHARLES SCHUCHERT OF THE U. S. NATIONAL MUSEUM sailed for Europe on June 24th. He will represent the Museum at the International Congress of Geologists in Vienna. Previous to the meeting he will spend his time studying museum methods and collecting fossils, particularly in the Silurian of Gotland and England, the Ordovician of Russia and the Devonian of the Eifel region. After the meeting of the Congress, Mr. Schuchert intends to devote his time until his return in November chiefly to a study of European Silurian and Devonian rocks in furtherance of his work on these systems in America.

MR. G. H. STONE OF COLORADO SPRINGS reports that a deposit of coal has recently been found on Turkey creek, about one mile south of the north line of Pueblo County, Colo. It is on the eastern slope of the Turkey Creek arch as it is termed by Gilbert in the Pueblo Folio, U. S. G. S. The stratigraphy is unmistakable, the rock in which the coal is found being mapped by Gilbert as Dakota and near-by exposures being found of all horizons from the Red Beds up to the Montana. The massive sandstone stratum in which tracks of saurians have been found directly overlies the principal coal bed. The sandstone strata are parted by several beds of dark carbonaceous shale, and in many places by thin sheets and bodies of coal. Some of these are narrow and appear to have been derived from a single plant or branch. The thickest coal bed thus far found is about 20 inches in thickness. Only a little exploration has as yet been made. The coal contains 54 per cent of fixed carbon, and it runs rather high in ash but low in water and sulphur. It can be used by blacksmiths, it having a higher heating power than the ordinary lignite of this region.

Coal of poor quality of Dakota age is found near Grand Junction and in several other places in southwestern Colorado, but so far as I know this is the first time coal has been found in Colorado east of the mountains.

Yours truly J. P. Lesley.

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THE

AMERICAN GEOLOGIST.

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J. PETER LESLEY.

By PERSIFOR FRAZER.

PORTRAIT—PLATE XIX.*

By the death of J. Peter Lesley, the old time type of scientific man is left almost without a representative. He was born in Philadelphia, on Sept. 17th, 1819. After completing his studies in the University of Pennsylvania, in 1838, he was appointed an assistant of professor Henry D. Rogers, on the First Geological Survey of Pennsylvania. Though his services were used in various regions, he was assigned to field work, chiefly in the bituminous coal measures, but also in the anthracite region.

On the temporary pause in the prosecution of this Survey in 1841, he studied Theology, in the Princeton Seminary, from 1841 to 1844, interspersing his religicus with much secular work for the Geological Survey.

Nature combined in him, an artist and topographer, in a degree rarely witnessed, and it was manifest that he never could forsake, for an indefinite time, the field in which he stood without a rival. By a legitimate use of the imagination he transformed many apparently incongruous field notes into orderly structure, often revealing new laws of plication, which afterwards proved of inestimable value in calculating the available mineral treasure in a given area.

It was no wonder that Henry D. Rogers could not dispense with Lesley's services, either while a student at Princeton, or later, when the Pennsylvania legislature renewed the appropriation for a final report. In the meantime he had concluded his studies and received his license to preach in 1844, upon

* Sincere thanks are rendered to the Editor of "Mines and Minerals" for permission to use this plate which is considered by Prof. Lesley and family the best likeness of him.

which he went to Europe and studied in the University of Halle during the winter of 1844-45.

Returning to America he became a colporteur for the American Tract Society in Northwestern Pennsylvania. Going to Boston in 1846, at the instigation of professor Rogers, he accepted the pastorate of a Congregational Church in Milton, Mass., and officiated there till 1851, when in consequence of a change of his religious views, he gave up his ministry and returned to Philadelphia as a reporting geologist.

The clear insight into the complicated geological structure of his native state which his studies in constructing the geological state map had given him, caused his opinion to be sought from all parts of the country; for not only was the capital from many states interested in the oil and coal of Pennsylvania, but from the completeness of his presentation of the paleozoic rocks their interpretation there furnished the key to their structure elsewhere.

He never organized this great business, which would inevitably have realized for him a large fortune, but attended to it personally as far as he could and let the remainder go.

He was very much hampered in geological reporting by his duties as secretary of the Iron and Steel Association; secretary of the American Philosophical Society; and editor of the Bulletin of the one, and of the Transactions and Proceedings of the other. These latter occupations chained him in Philadelphia, while his professional engagements in examining mineral properties would have furnished field occupation to two men like himself during the entire year.

It was these conflicting duties and demands which kept his sensitive mind in continual distress and brought about a nervous exhaustion which compelled him to seek relief several times in Europe. In addition to his engrossing editorial duties above referred to, he published in 1859 for the Iron and Steel Association the "Iron Manufacturer's Guide," a large volume of permanent value, and carried out a new and original system of cataloguing the extensive library of the American Philosophical Society. Besides this, he was the "presenter" at the fortnightly meetings of the Society, the active recorder of its minutes, the suggester of its policy, and, principal framer of its resolutions to carry that policy out. He took part in most of the discussions (which indeed seemed tame, when his pleasant

mellow voice was not heard) and when nothing of interest was before the Society, drew upon his stores of information in order that those who had taken the trouble to attend might not depart without profit.

In 1872, on the reorganization of the faculty of the University of Pennsylvania, he was elected by the trustees professor of geology and mining, and dean of the faculty of science. In 1874 the state of Pennsylvania established a second geological survey and Lesley was named as director. The hundred volumes and thousands of maps and sections of this survey will be his most enduring monument. Every line of text and illustration in the survey passed under his eye and not infrequently he made alterations in both,—sometimes without the approval of the author and in such cases in disregard of his own vehement protest against similar action of his former chief, H. D. Rogers: but he always believed such alterations absolutely necessary.

The character of professor Lesley was composite, but wholly noble. He was really two closely united men; the one, an artist and *Schwarmer* to the tips of his fingers: a master of persuasive elocution, of incisive rhetoric, and of the subtle art of design with pencil and brush. He was an enthusiast and an optimist—all this by nature. But another man was intertwined with this natural man, viz., the artificial business man, whose duties it was to keep severe watch over the natural man's expressions and judgments, to reduce his speculations to the practicable, and to lower the tone of his professional utterances from inspiration to business. This man was often lamentably melancholy, undemonstrative and even cynical, yet from a trifle which happened to strike his mind in a certain way, the entire artificial man was thrown off in an instant and he was the genial, hopeful, natural Peter Lesley once more.

Impressionable and emotional, as are all artistic temperaments, there was nothing sordid or base even in his faults, which were chiefly due to an abstraction which often made him oblivious of the present, and sometimes impaired his appreciation of the relative proportions—the mental perspective—of things. He was generous to prodigality towards others while careless of his own ease and comfort. "Plain living and high thinking" was the motto on which he moulded his life. His tall and rugged figure, imposing though disdainful of the em-

bellishment of dress reminded one of Abraham Lincoln; which comparison was strengthened by his rich and musical voice. His phrases were choice, clearly enunciated and full of imagery, and his lectures comprehensive and graceful. When, warming with interest in what he was saying as often happened, his sad expression melted into one of enthusiasm and smiles, the atmosphere around his auditors seemed lightened as when the sun breaks through a cloud. Like the late lamented Dr. Joseph Leidy he hated the intrigues and animosities inseparable from holding one's head above water even among the illuminati, but unlike Dr. Leidy he was not uniformly successful in keeping out of such unpleasantnesses, and when once in he rendered yeoman's service with tongue and pen for the side he thought in the right, which was most frequently the winning side.

He seemed a born interpreter of phenomena, so vividly his imagination pictured the course of events which led to them; and it is not surprising that the evolution of language from the simplest ideographs and symbols of the earliest races enchained him. Thus he threw himself with heart and soul into Egyptology and evolved a world of curious interest from the mystic letters B A R. His hieroglypis, which decorated as borders several apartments of his house, 1008 Clinton St., Philadelphia, were beautifully done, as was every map, page of manuscript, or illustration from his pen or brush.

His friends were devoted to him, as he to them, so that although many sorrows and disappointments crossed his path, their constancy and still more the gentle elevating influence of his wife and daughters, gave him a balance of happiness for which the average man might be justly grateful, though it was well deserved.

He died peacefully in Milton, Mass., on June 1st, 1903.

He was among the first geologists to contribute to our understanding of the rock oil problem; he was one of the original members of the National Academy of Sciences; president of the American Association for the Advancement of Science, 1884); U. S. Commissioner to the "Exposition Universelle," 1867; author of "Man, his origin and destiny from the platform of the sciences," "Coal and its topography," etc.

On February 13th, 1849, he married Susan Inches Lyman of Northampton, Mass., by whom he had two daughters, all of whom survive him.

ON THE FAUNAL PROVINCES OF THE MIDDLE DEVONIC OF AMERICA AND THE DEVONIC CORAL SUB-PROVINCES OF RUSSIA, WITH TWO PALEOGRAPHIC MAPS.

By CHARLES SCHUCHERT, U. S. National Museum.

PLATES XX-XXI.

The recent work on the corals of Russia by Lebedew* gives Americans their first opportunity for more or less detailed comparisons among the coral faunas of that Empire and those of Europe and America. In this paper will be given (1) an abstract of Lebedew's conclusions, (2) some observations by the present writer on the affinity of the coral subprovinces of America and Europe, and (3) extended remarks on the "American" and "Eurasiatic" provinces of North America.

Devonic corals are often of very wide geographic distribution and from this fact have considerable value as indicators for the intercommunication of seas and oceanic provinces. It seems almost certain that many of the world-widely distributed species are loosely defined and contain more than one form, and that many of the genera also lack precision. This, however, cannot militate against the general conclusions here drawn, since it still remains a fact that the forms so recognized are closely allied, if not identical.

Lebedew finds that the Devonic corals of Russia occurring in ten regions can be grouped into three subprovinces each having a more or less uniform faunal development. These are:

1. *The West European type,* embracing the areas of West Europe, Poland, Transkaukasia and Petchora-land.

2. *The Central Russian type,* embracing the area of the main Devonian field of Russia and Northwest and Central Russia.

3. *The Ural-Altai type,* including the Urals (also the Mugadzhar Mts.), Altai, West Siberia and Turkestan.

WEST EUROPEAN TYPE.

Poland.—In this country occur fifty-seven species of Devonic corals. Only eight of these are identical with or are repre-

* Die bedeutung der Korallen in den Devonischen ablagerungen Russlands [in Russian with an extended abstract in German]. By N. LEBEDEW. (*Mem. du Comite Geologique,* xvii, No. 2, 1902, pp. i-x, 1-130 in Russian, 137-180 in German, pls. I-V).

sented by closely related forms in Northwest and Central Russia, and five of these are very widely distributed forms.

Of the twenty-eight species found in the upper zones of the Middle and the entire Upper Devonic, but eight occur in Northwest and Central Russia. However, when comparison is made with Germany, "one finds that all the forms found in the various zones of Poland also occur in Germany." This holds true even to varieties.

The developmental aspect of the corals is also in agreement with the balance of the fauna, showing that the Northwestern and Central Russian Devonic is a distinct subprovince from that of West Europe. Lebedew therefore concludes that these areas were not directly connected. Such characteristic West European or Poland forms as *Cyathophyllum quadrigeminum* Goldfuss, the genus *Spongophyllum*, and *Calceola sandalina* are absent in Northwest and Central Russia.

Of the fifty-seven species of corals of Poland, one finds that but ten are analogous with American forms, and further, that the species characteristic of one area are absent in the other. A coral of special interest in this connection is *Calceola sandalina* which is absent in America but is known in the Urals and even in the Altai.

"The character of the coral faunas of the Devonian of Poland is typically West European in its essential characters as: (1) the scarcity of corals in the Lower Devonian, (2) the preponderance of massive forms of *Favosites* in the Lower, and branching species in the Middle and Upper Devonian, (3) the great abundance of operculate corals of the families *Calceolidae* and *Cystiphyllidae* in the lower zones of the Middle Devonian, (4) the great horizontal distribution of *Calceola sandalina* in the Middle Devonian, (5) the reappearance of *Acervularia* and *Phillipsastraea* in the upper zones of the Middle and lower beds of the Upper Devonian, and (6) the absence of corals in the upper horizons of the Upper Devonian." (p. 159.)

Transkaukasia.—But one coral horizon has been clearly determined although there are more. This is the zone of *Calceola sandalina.* Besides this species it has *Favosites, Alveolites, Heliolites, Cyathophyllum, Endophyllum, Mesophyllum, Phillipsastraea* and *Cystiphyllum.* "Nearly all of the forms are common also in the Devonian of West Europe." (p. 175.)

Petchora-land.—Here the Middle Devonic has eleven species and the Upper Devonic twelve, or together seventeen forms. The faunal aspect is that of West Europe and not that of the Urals. This is shown by the occurrence in both regions of rare forms, as *Cyathophyllum minus* and *C. kunthi.* These species have much stratigraphic significance in Germany. A more decisive connection between the coral faunas of Petchora-land and West Europe is shown by the presence of *Campophyllum* in the Upper Devonic; also for the northern region of Russia but not for the Urals where another species of the genus is found. Further faunal connection is shown by the presence of *Acervularia* and *Phillipsastraea. Calophyllum,* always rare in species, is represented by one form and is further proof "that there was close connection between the Devonic basin of West Europe and that of Petchora-land." The next nearest affinity is with West Siberia and the Altai.

CENTRAL RUSSIAN TYPE.

The main Devonic field of European Russia.—This region is poor in corals, though certain species make considerable reefs in the upper zone of the Middle Devonic. Here nine species are known and, as is to be expected, five of these also occur in Central Russia. These are *Aulopora serpens, A. tubaeformis, Favosites cristatus, Cyathophyllum caespitosum* and *C. hexagonum.* The other species are *Aulopora orthocerata, Chaetetes intricatus, Favosites reticulatus* and *Strombodes.*

The characterizing feature of the coral faunas of North and Central Russia is the absence of *Coenites, Striatopora, Phillipsastraea, Acervularia* and *Endophyllum.*

Central Russia.—Here twenty-seven species are known. These are mainly from two horizons, *i.e.,* fifteen species from the upper beds of the Middle Devonic and the same number from the uppermost zone of the Upper Devonic. The latter is strongly tinged with Carboniferous species as ten of the fifteen also pass upward.

Of the fifteen Middle Devonic species, twelve also occur in West Europe but only five in Poland and these are cosmopolitan forms. This area has *Favosites* 1, *Chaetetes* 1, *Syringoporidae* 5, *Cyathophyllidae* 8.

Note the absence here of *Cystiphyllum, Acervularia* and *Phillipsastraea,* forms widely distributed in the Middle and lowest Upper Devonic.

There was no direct connection between West Europe and Central Russia. One American species occurs here.

Northwest and North Russia.—In this region but nine species are known in the upper part of the Middle Devonic and the lower zone of the Upper Devonic, but in places they form reefs of considerable extent. These belong to the families *Favositidae, Chaetetidae, Syringoporidae, Cyathophyllidae* and *Cystiphyllidae.*

The corals of this region have a decided relationship with those of Central Russia. Compared with those of the Timan region there is a great difference and the conclusion is warranted that no direct connection existed between these areas during Devonic time.

THE URAL-ALTAI TYPE.

Urals.—Here we have sixty-six species distributed over a great area extending from north to south. The *Favositidae* and *Cyathophyllidae* are most abundant. The great coral horizons are in the lower and upper zones of the Lower Devonic, and the middle and upper beds of the Middle Devonic.

The lowest Lower Devonic is characterized by *Favosites* (some Silurian species) and *Cystiphyllidae.* The upper zone of the Lower Devonic has such characteristic species as *Cyathophyllum caespitosum, C. ceratites,* etc.

Comparing the corals of the Urals with those of West Europe and America, it is seen that the lowest Lower Devonic species are of the West European type and that in the upper zones of the Lower Devonic the first distinctly American species are met, as *Favosites forbesi* and *Syringopora hisingeri.* The distinctly American species increase in number in the Middle Devonic where occur *Favosites placenta, F. nitellus, Syringopora perelegans, S. nobilis, S. tabulata* and *Emmonsia hemispherica.* In the Upper Devonic, corals are rare and the data for comparison are not satisfactory.

"We recognize that the Devonian corals of the Urals have in general a great resemblance to those of West Europe, although here also appear strange elements as local and American forms. These occurrences seem to show that between the Devonian of the Urals and that of North America there was a less decided connection than between the former and West Europe." (p. 167.)

Lebedew's extensive tables show that in the Middle and Upper Devonic faunas of the Urals there are no *Acervularia, Endophyllum, Mesophyllum, Spongophyllum* or *Diphyphyllum* and but one *Phillipsastraea,* which occurs in the basal Middle Devonic. In this respect these Ural faunas have the characteristics of the Central Russian type, and it is strange that Lebedew does not call attention to this decided affinity.

Mugadzhar Mts.—These mountains are directly south of the Urals and terminate towards the Aral sea. But ten species are known here. In the upper Middle Devonic occur *Alveolites* 1, *Cyathophyllum* 2, *Acervularia* 2, *Phillipsastraea* 3. The author remarks that the faunal aspect is rather that of the Altai and West Siberia than that of the Urals.

Turkestan.—The corals of this area are too few in number and are otherwise not sufficiently significant to indicate faunal relationship with the other areas.

Altai and West Siberia.—Here are known sixty-six species. Of these "twenty-five are common to the Urals, eight are identical with or very closely related to American species, while the greater part of the remainder, with the exception of local forms, recur in West Europe. In general, the corals of the Altai and West Siberia resemble those of the Urals (and the Mugadzhar Mts.) with respect to (1) relationship, (2) the preponderance of West European forms, and (3) the noticeable recurrence of American species. In connection with this it is to be noted that here, as there, the American species are found in the same homotaxial horizons: they concentrate themselves in the main in the adjoining horizons of the Lower and Middle Devonian, while the lower zone of the Middle and the entire Upper Devonian are free of them." (p. 172.) The absence of American species in these formations he thinks is probably due to differing geological horizons in the two areas.

Decidedly characteristic for the Urals (including the Mugadzhar Mts.), Petchora-land, and the Altai (with West Siberia), appear to be certain corals that occur only in these regions. Such are *Alveolites goldfussi* Billings, *Heliolites porosus* Goldfuss, *Cyathophyllum hypocrateriforme* Goldfuss, *Acervularia pentagona* Goldfuss, *Phillipsastraea bowerbanki* Goldfuss, *P. annas* Goldfuss, *Cystiphyllum vesiculosum* Goldfuss. *Phillipsastraea* and *Acervularia* are characteristic of the

upper horizon of the Middle and the lower zone of the Upper Devonic, and their occurrence in numerous species is a feature that marks and distinguishes the three above named regions. The relationship of the Altai is also greater with the Mugadzhar Mts. than with the Urals.

In the Middle Devonic of the Altai-West-Siberia region occur *Favosites* 7, *Coenites* 1, *Striatopora* 1, *Roemeria* 1, *Alveolites* 3, *Heliolites* 1, *Aulopora* 2, *Syringopora* 1, *Amplexus* 2, *Calophyllum* 1, *Cyathopaedium* 1, *Cyathophyllum* 5, *Mesophyllum* 2, *Spongophyllum* 2, *Phillipsastraea* 3, *Cystiphyllum* 1, *Calceola sandalina.*

MIXED TYPE.

North Siberia.—The corals of this region are of species that have "immense vertical and horizontal distribution, as *Favosites cristatus, Alveolites suborbicularis, Aulopora serpens, Cyathophyllum caespitosum* and *C. hexagonum.*" Baron Toll, after a review of the entire fauna of North Siberia, concluded it to be a mixture of Ural and American types and of the Stringocephalus horizon. "It is worthy of remark that the deposits of the Stringocephalus horizon, which in West Siberia do not show any decided affinity with the same deposits of America, have, farther to the east in the region explored by Toll, forms in common to both these areas."

SUMMARY.

West European type.—The Middle and Upper Devonic coral faunas of this subprovince are marked by an abundance of *Cyathophyllum,* massive and branching *Favosites, Cystiphyllum, Acervularia, Spongophyllum, Endophyllum, Mesophyllum, Phillipsastraea, Alveolites, Campophyllum* and *Stromatopora,* a less abundance of *Pachypora, Striatopora, Heliolites, Aulopora,* and the presence of *Amplexus, Calophyllum, Coelophyllum, Metriophyllum, Hadrophyllum, Microcyclus, Pachyphyllum, Calceola, Chaetetes, Michelinia, Plagiopora, Roemeria* and *Syringopora.*

Central Russian type.—The Middle and Upper Devonic coral faunas of this subprovince are marked by a paucity of species. *Favosites* is represented by a few forms, while the genera *Coenites, Striatopora, Phillipsastraea, Acervularia* and *Endophyllum* are absent. The faunas consist essentially of *Syringoporidae* and *Cyathophyllidae.*

Ural-Altai type.—The Middle Devonic coral fauna of this subprovince in its western and eastern limits is marked by an abundance of *Favositidae, Cyathophyllidae* and *Syringoporidae.* To these in the west (Urals) are added sparingly *Alveolites, Heliolites* and *Calceola sandalina* and an abundance of *Cystiphyllum.* In the southwest (Mugadzhar Mts.) are known only *Acervularia, Phillipsastraea, Alveolites* and *Cyathophyllum.* In the eastern region, besides the three families mentioned for the western area, there also occur in abundance *Mesophyllum, Spongophyllum, Phillipsastraea* and more rarely *Acervularia, Cystiphyllum, Calceola sandalina, Heliolites porosus,* etc. This area contrasts strongly with that of the western area. Another feature of the Ural region is the occurrence of American species, as *Favosites placenta, F. nitellus, Emmonsia hemispherica, Syringopora perelegans, S. nobilis* and *S. tabulata.*

An examination restricted to the corals of the Middle Devonic of the Ural Altai region seemingly decides that the Ural faunas have the Central Russian type. In all of these there is an abundance of *Acervularia, Phillipsastraea* and *Endophyllum,* while these genera are prominent in the other areas, as the Mugadzhar Mts., Altai Mts. and West Siberia.

The Faunal Provinces of the American Middle Devonic.*

In the Middle Devonic of North America there are probably more than 600 described species of corals,† and of these the writer has found that 106 occur in two or more widely separated places. These are listed in the appended table and their distribution noted in eleven columns.

The table shows clearly that the corals of the various Onondaga localities belong to one province. Of the 53 widely dispersed species of Mackinac, 39 are also found in New York or Port Colborne and [illegible]t Louisville. Together these localities have 67 spe[illegible] these [illegible] 6 occur in Iowa or Wisconsin. Fi[illegible]smopolitan forms and are com[illegible]d Hamilton formations.

* [illegible]d barriers in eastern North Ame[illegible]ese researches the writer con- t[illegible]nk him for the great aid [illegible]

[illegible]e will doubtless

These facts show that either there is no Onondaga in Wisconsin, Iowa and Missouri, or that the equivalent faunas found in these states were separated from the eastern area by a nearly completely effective barrier preventing intermigration. The former hypothesis is believed to be the truth as will be seen later.

The corals of the Hamilton of New York, western Ontario, and Louisville are also harmonious and belong to one province. Of the 34 widely dispersed species found about Thedford, Ontario, 11 occur in New York, about 15 at Louisville, and the same number at Thunder Bay. The Hamilton of this area received many of its species from the Onondaga below, and the coral faunas of these two formations belong to one province and form an evolutionary series.

Comparing this eastern area with that of Traverse Bay, Michigan, Milwaukee, Wisconsin, Iowa and Missouri, a very marked dissimilarity is noted. Of the 34 widely dispersed species of Thedford, which is the westernmost locality of the eastern area having a typical Hamilton fauna, but 7 are found at any one place in the western area mentioned above. These are 1, *Acervularia davidsoni,* 2, *A. profunda,* 3, *Aulopora serpens,* 4, *Favosites alpenensis,* 5, *F. digitatus,* 6, *F. placenta,* and 7, *Heliophyllum juvenis.* Two of these, numbers 3 and 6, have a world wide distribution, while only one, *F. placenta,* occurs in New York. Out of a total of 106 widely dispersed Middle Devonic corals, but 24 occur in western Michigan, Wisconsin and Iowa. Of these 24 species, but 6 occur in New York, the other 18 not passing beyond the western half of the eastern province.

Stromatoporoids are not rare in the eastern province but are more prominent along the western side of this area and particularly about Alpena, Michigan. In the western province they are far more prominent, and this is especially true for the Petosky region. Not only this, there are also species in the western area not seen in the eastern.

The brachiopods along the northern side of the eastern province are harmonious from central New York southwestward to Columbus, Ohio, and westward to Thedford, but grow less so toward Thunder Bay, Michigan. While the last named region has a noticeable blending of species of both the eastern

and western provinces, yet it is more properly placed in the eastern area. Here occur such characteristic species of the eastern area as *Spirifer mucronatus arkonensis, S. granulosus, S. audaculus, S. divaricatus, Cyclorhina nobilis, Pentamerella pavillionensis, Chonetes coronatus,* etc. Of species of the western area one finds an abundance of *Stropheodonta erratica,* also *Gypidula, Spirifer subattenuata* and *S. asper.*

The common brachiopods of the western area are decidedly different from those of the eastern area, and while there is a considerable number of species common to both, yet these are forms of great geographic and geologic distribution. In the western area occur *Newberria, Gypidula, Cyrtina* with the fold and sinus plicated, *Pugnax,* a great abundance of *Stropheodonta* of the *S. erratica* group, and *Schizophoria.* Of *Spirifer* there are such characteristic forms as *S. pennatus,* while the absence of *S. mucronatus* and *S. granulosus* is significant.

The crinoids and blastoids of the western area also are specifically different from those of the eastern area, while those of Alpena agree fairly well with the species found in the Louisville, Kentucky, and Columbus, Ohio, regions.

Teller and Monroe* have listed the Middle Devonic fauna of Milwaukee, Wisconsin, and enumerate about 173 species. Much of the material remains undescribed and the writer believes that some of the brachiopods, but more particularly the pelecypods, will be found to have been erroneously identified. However, accepting the list nearly as it stands, it is seen that 97 species are specially determined. Of these, 73 also occur in the eastern area. Adding to the undetermined material the 20 species restricted to the western province, we have a total of 92 forms not known in the eastern area.

A further analysis of this list shows that not a single cephalopod, gastropod (excepting *Platyceras* which has no stratigraphic significance), or crinoid is common to the Milwaukee and the eastern areas. Further, of the great coral fauna of the eastern sea (about 600 species), only three forms occur at Milwaukee. Of the eastern brachiopods the following are found: *Atrypa spinosa, Chonetes scitulus, C. vicinus, Craniella hamiltoniae, Cyrtina hamiltonensis, Spirifer conso-*

* *Jour. Geol.*, vii, 1899, pp. 272-283.

brinus, Eunella lincklaeni, Lingula complanata, L. maida, L. spatulata, L. paliformis, Orbiculoidea lodiensis, Orthothetes arctistriata, Pholidostrophia iowaensis, Schizophoria striatula, Stropheodonta demissa and *S. perplana.* This may seem a formidable list, but on careful scrutiny it proves of little consequence, for no paleontologist would pay much attention to species of *Lingula, Craniella, Orbiculoidea, Chonetes, Atrypa* and *Orthothetes,* or to *Schizophoria striatula, Stropheodonta demissa, S. perplana* and *Cyrtina hamiltonensis* for the determination of faunal differentiation. Eliminating these there remain *Spirifer consobrinus, Eunella linckaeni* and *Pholidostrophia.* Against their presence, note the absence at Milwaukee (also Iowa) of nearly all the characteristic New York Hamilton species, such as *Spirifer granulosus, S. mucronatus, S. divaricatus, Tropidoleptus, Vitulina, Rhipidomella, Stropheodonta concava,* etc. On the other hand, note the presence at Milwaukee of the characteristic western species, as an abundance of *Schizophoria, Spirifer pennatus, S. subvaricosus, Cyrtina* with plicated fold and sinus, and *Dielasma calvini.*

It should also be noted here that of the 73 species common to the western and eastern regions, no fewer than 23 also occur in the Upper Devonic of New York. This fact indicates that either some of the identifications are not accurate or that the Milwaukee Devonic includes not only a part of the Hamilton but also a part of the Portage of New York, and also that the former region has probably received migrants from the east. The writer thinks the latter view the correct one as it has been demonstrated by Clarke, Williams and Calvin that the High Point Chemung faunule is a migration of a part of the Lime Creek, Iowa, Upper Devonic. These higher beds of the Upper Devonic have been removed in the Milwaukee-Chicago area* but in Michigan are present as the Antrim formation. The characteristic "Black shale" phase of the Upper Devonic extending from New York to eastern Michigan is still present in northwestern Michigan but is not known in northern Illinois, Iowa or Missouri.

Contrasting the Milwaukee fauna with that of Thedford in western Ontario, quite a different development is seen. The

* See WELLER, *Jour. Geol.* vii, 1899, p. 483. It is here shown that Devonic and probably Upper Devonic fossils are found in crevices of the Niagara dolomites fifteen miles west of Chicago at the Elmhurst quarries, Illinois. Also see Folio No. 81, *U. S. Geol. Surv.*, 1903, p. 3, by ALDEN.

Thedford Hamilton fauna is listed by Shimer and Grabau* and is compared with that of Eighteen Mile Creek, to the west of Buffalo, New York. The Thedford fauna has 236 named species and of these 87 also occur near Buffalo, but 129 in the entire state of New York. If we add the 12 other species known in this state only in the Onondaga, it follows that 141 New York Middle Devonic species are common to the two places, or that 61 per cent of the Thedford fauna also occurs in New York. Not only is the percentage of species common to the two places high, but the forms are also those most characteristic of the New York Hamilton.

In a straight line it is 330 miles from Thedford west to Milwaukee and 180 miles from the first named place north to Alpena on Thunder Bay, Michigan. The latter region still has many of the characteristic Thedford Hamilton forms, but, as stated elsewhere, has also a considerable number of western species. This mixed fauna—Traverse— therefore occurs between Thunder Bay on the east side of Michigan, and Milwaukee on the west side of Lake Michigan.

It seems to the writer that the facts just mentioned demonstrate that there is a very marked difference in the Middle Devonic faunas of Missouri and Iowa when contrasted with those of Thedford, Ontario, southern Illinois and the Louisville, Kentucky, region. The former places belong in the Dakota sea† and the latter in the Mississippian sea.‡ This is also the conclusion of Calvin and he writes in 1898 as follows:

"The Devonian system of Iowa was deposited in an area geologically isolated from that in which the eastern Devonian was developed. The conditions of sedimentation were different in the two areas. The order and succession of faunal conditions were not the same. The eastern Devonian faunas, subjected to certain physical conditions and undergoing certain

* *Bull. Geol. Soc. Amer.*, xiii, 1902, pp. 149-186.

† Williams names this sea the Dakota channel but it is more properly regarded a sea, not only because of its great length, but of its great width as well. It is defined as follows:

"From the north a wide open oceanic channel swept from the Mackenzie river valley region across British America, the Dakotas, Nebraska, and Kansas [also Iowa, south-eastern Minnesota, Missouri, northern Illinois and south-eastern Wisconsin] far into and through the western Texas region to the south. This channel was bounded on the west by the extensive Archean islands or edges of land constituting the eastern axis of the present Rocky mountains." *Amer. Jour. Sci.*, May, 1897, p. 394.

‡ For definition of Mississippian sea see WALCOTT, *Amer. Assoc. Adv. Sci.*, 1894, pp. 129-169. ULRICH and SCHUCHERT, *Bull. 52, N. Y. State Mus.*, 1902, p. 636.

modifications, probably migrated from the northeast along the eastern border of the continental nucleus, while the western faunas of the same period seem to have come from the northwest along the western border of the Devonian continent."*

As has been stated, the region between Alpena, Michigan, on the west side of Lake Huron, and Milwaukee on the west side of Lake Michigan, has a mixed fauna, *i.e.*, the Traverse fauna is a commingling of Mississippian and Dakota species. This mixed Middle Devonic fauna is continued southward as far as Louisville and Lebanon, Kentucky, on the west side of the Cincinnati island, while immediately on the eastern side of this island at Columbus, Ohio, the faunal sequence is more decidedly that of New York. The paleontologic work of Whitfield on the Devonic beds of central Ohio† shows unmistakably that the succession here is in agreement with western New York, *i.e.*, the Manlius is followed by the Onondaga, Hamilton, Portage and Chemung faunas. In other words, the New York Hamilton fauna retains its characters more strongly along the shores of Laurentia, Appalachia, and the eastern side of the Cincinnati island, while the Traverse Hamilton fauna followed the eastern shore of the Kankakee peninsula and the western side of the Cincinnati island. To the east of the Cincinnati island and west of Appalachia was the Cumberland basin (Williams‡), while to the west of the former and east of the Kankakee peninsula was another basin which may be called the *Indiana basin.* It is in the latter area that the Traverse Hamilton fauna occurs. The Middle Devonic faunas of the Mississippian sea belong to the "American Province"§ or to the "North Helderberg Sea" of Frech.‖ Those of the Dakota sea have the general faunal facies of the "Eurasiatic Province."

Whatever may be the exact age of the lower formations of the Iowa Middle Devonic, it is certain that this area does not have the Mississippian Onondaga fauna. Either Iowa with

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* *Iowa Geol. Surv.*, viii, p. 221.

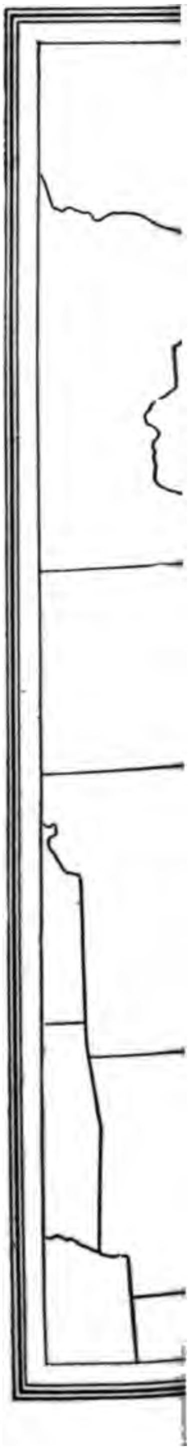
† *Geol. Surv. Ohio*, vii, 1893, pp. 419-464. See also ORTON in same volume, pp. 18-26.

‡ The "Cumberland gulf" or basin of Williams should not be confounded with the Cumberland mediterranean of Ulrich and Schuchert. The former belongs to the Mississippian province of Devonic time while the latter is an arm of the North Atlantic sea beginning with the Ontario and continuing to the close of the Oriskanian.

§ KAYSER, *Lehrbuch der Geologie*, sec. ed., 1902, p. 154.

‖ *Lethaea Geognostica*, 1 Theil, *Lethaea Paleozoica*, ii, pt. 1, 1897, paleographic map III.

THE AMERI



There was no direct connection between West Europe and Central Russia. One American species occurs here.

Northwest and North Russia.—In this region but nine species are known in the upper part of the Middle Devonic and the lower zone of the Upper Devonic, but in places they form reefs of considerable extent. These belong to the families *Favositidae, Chaetetidae, Syringoporidae, Cyathophyllidae* and *Cystiphyllidae.*

The corals of this region have a decided relationship with those of Central Russia. Compared with those of the Timan region there is a great difference and the conclusion is warranted that no direct connection existed between these areas during Devonic time.

THE URAL-ALTAI TYPE.

Urals.—Here we have sixty-six species distributed over a great area extending from north to south. The *Favositidae* and *Cyathophyllidae* are most abundant. The great coral horizons are in the lower and upper zones of the Lower Devonic, and the middle and upper beds of the Middle Devonic.

The lowest Lower Devonic is characterized by ***Favosites*** (some Silurian species) and *Cystiphyllidae.* The upper zone of the Lower Devonic has such characteristic species as *Cyathophyllum caespitosum, C. ceratites,* etc.

Comparing the corals of the Urals with those of West Europe and America, it is seen that the lowest Lower Devonic species are of the West European type and that in the upper zones of the Lower Devonic the first distinctly American species are met, as *Favosites forbesi* and *Syringopora hisingeri.* The distinctly American species increase in number in the Middle Devonic where occur *Favosites placenta, F. nitellus, Syringopora perelegans, S. nobilis, S. tabulata* and ***Emmonsia*** *hemispherica.* In the Upper Devonic, corals are rare and the data for comparison are not satisfactory.

"We recognize that the Devonian corals of the Urals have in general a great resemblance to those of West Europe, although here also appear strange elements as local and American forms. These occurrences seem to show that between the Devonian of the Urals and that of North America there was a less decided connection than between the former and West Europe." (p. 167.)

modifications, probably migrated from the northeast along the eastern border of the continental nucleus, while the western faunas of the same period seem to have come from the northwest along the western border of the Devonian continent."*

As has been stated, the region between Alpena, Michigan, on the west side of Lake Huron, and Milwaukee on the west side of Lake Michigan, has a mixed fauna, *i.e.*, the Traverse fauna is a commingling of Mississippian and Dakota species. This mixed Middle Devonic fauna is continued southward as far as Louisville and Lebanon, Kentucky, on the west side of the Cincinnati island, while immediately on the eastern side of this island at Columbus, Ohio, the faunal sequence is more decidedly that of New York. The paleontologic work of Whitfield on the Devonic beds of central Ohio† shows unmistakably that the succession here is in agreement with western New York, *i.e.*, the Manlius is followed by the Onondaga, Hamilton, Portage and Chemung faunas. In other words, the New York Hamilton fauna retains its characters more strongly along the shores of Laurentia, Appalachia, and the eastern side of the Cincinnati island, while the Traverse Hamilton fauna followed the eastern shore of the Kankakee peninsula and the western side of the Cincinnati island. To the east of the Cincinnati island and west of Appalachia was the Cumberland basin (Williams‡), while to the west of the former and east of the Kankakee peninsula was another basin which may be called the *Indiana basin.* It is in the latter area that the Traverse Hamilton fauna occurs. The Middle Devonic faunas of the Mississippian sea belong to the "American Province"§ or to the "North Helderberg Sea" of Frech.‖ Those of the Dakota sea have the general faunal facies of the "Eurasiatic Province."

Whatever may be the exact age of the lower formations of the Iowa Middle Devonic, it is certain that this area does not have the Mississippian Onondaga fauna. Either Iowa with

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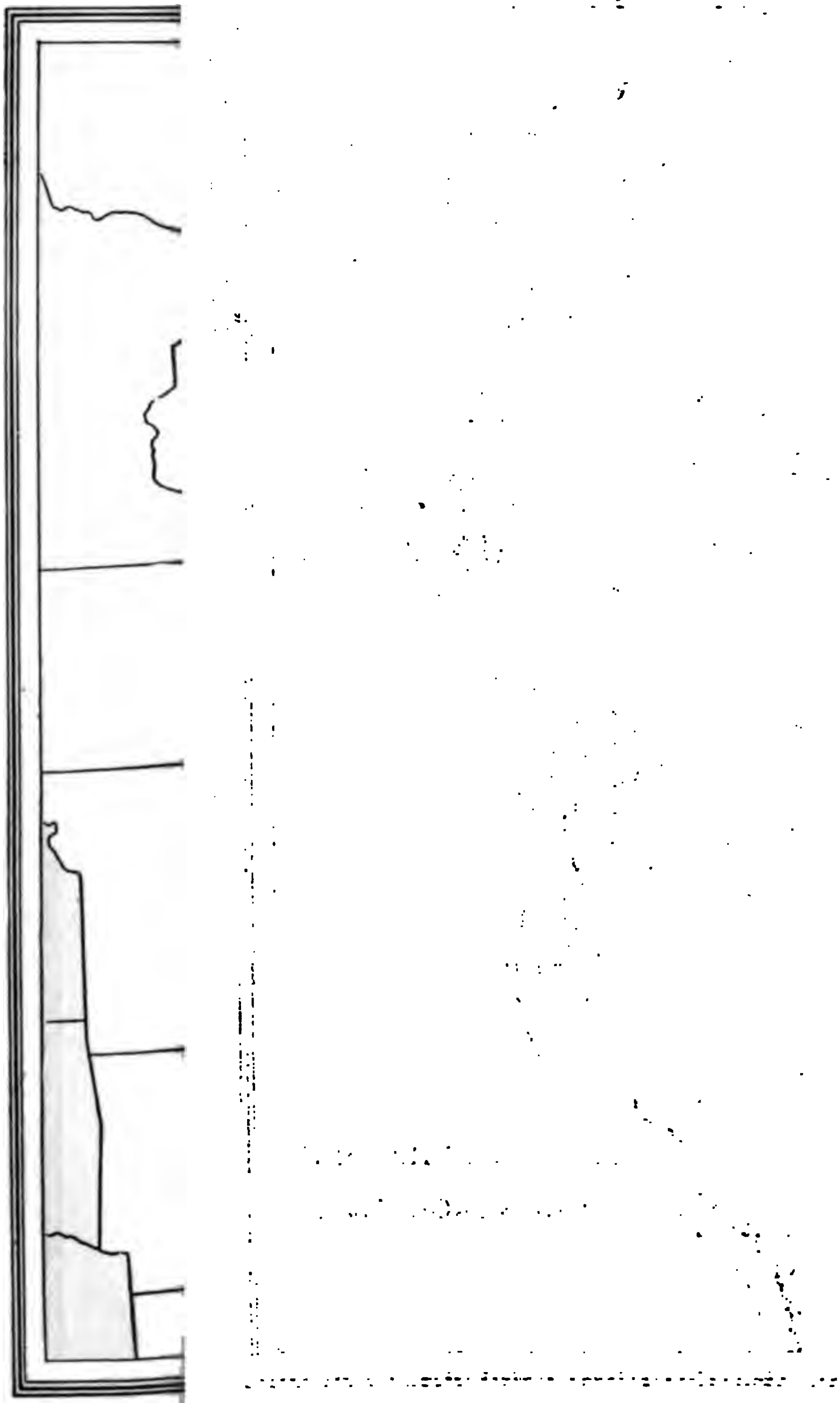
* *Iowa Geol. Surv.*, viii, p. 221.

† *Geol. Surv. Ohio*, vii, 1893, pp. 419-464. See also Orton in same volume, pp. 18-26.

‡ The "Cumberland gulf" or basin of Williams should not be confounded with the Cumberland mediterranean of Ulrich and Schuchert. The former belongs to the Mississippian province of Devonic time while the latter is an arm of the North Atlantic sea beginning with the Ontario and continuing to the close of the Oriskanian.

§ Kayser, *Lehrbuch der Geologie*, sec. ed., 1902, p. 154.

‖ *Lethaea Geognostica*, 1 Theil, *Lethaea Paleozoica*, ii, pt. 1, 1897, paleographic map III.



the adjoining areas was then land or the Kankakee axis was completely effective in separating the eastern and western seas.

Comparing the Mississippian Middle Devonic coral faunas with those of certain areas determined by Lebedew, it is seen that they have not the Eurasiatic facies. It is in vain that one seeks for such characteristic elements of the "West European type" as *Spongophyllum, Endophyllum, Mesophyllum, Campophyllum, Heliolites, Calophyllum, Coelophyllum, Metriophyllum, Pachyphyllum* and *Calceola.* On the other hand, a closer communication between Eastern America and Northwestern Europe is indicated by the fact that in these two regions are found in abundance massive and branching *Favosites,* some *Phillipastraea, Amplexus, Hadrophyllum, Microcyclus, Michelinia and Roemeria.*

The Dakota coral faunas occurring in western Michigan, Wisconsin, Iowa and Missouri and extending westward to the Pacific and northward from Arizona to the Arctic coast, are all of the Eurasiatic type. It is only in these western and northern areas of American Devonic provinces that many of the genera above noted as not found in eastern America occur, namely, *Spongophyllum, Endophyllum, Campophyllum, Heliolites* and *Pachyphyllum.*

The Devonic Eurasiatic faunas are now known in the Dakota sea from southern Minnesota south to Callaway and Moniteau counties, Missouri, north through Manitoba into the far north in the Mackenzie River basin and the Arctic coast of Alaska. In the "Cordilleran sea" (Walcott) these same faunas are found in southwestern Colorado, Bisbee and Rio Verde, Arizona (here occurs the Iowan Upper Devonic), White Pine and Eureka Districts, Nevada, and the Yellowstone Park; while in the "California sea" (Walcott) they also occur at many localities in northwestern California and southern Alaska.

The barrier that more or less effectively prevented the mingling of the faunas of the Mississippian and Dakota seas during Hamilton and Chemung times is here named the *Kankakee axis or peninsula.* To the writer it seems that during Onondaga time all of Iowa, Missouri and northern Illinois was land. After the beginning of Hamilton time, the Dakota

sea invaded the area of these states and spread northward through *Traverse straits* (taking its name from Traverse formation) along the western side of the Kankakee peninsula into northern Michigan where it came into more or less unrestricted communication with the Mississippian sea. The general trend of the Kankakee axis is northeast from southern Illinois to the region of the Kankakee river where it seems to be flexed, following the general trend of that stream and again bending, strikes northerly through the western part of the Lower Peninsula of Michigan. The change of strike along the Kankakee river seems to be due to another axis having a northwest-southeast direction and named by Gorby* the Wabash axis. The name for the heretofore unnamed axis has been taken from the Kankakee valley since it is to the west, south and east of this region that the lay of the Devonic deposits against the Niagaran and Cayugan formations can be observed in outcrops or by means of well records. In the south the Ohio and Mississippi rivers have eroded through the uplift where rocks of Middle and Upper Devonic age of the Mississippian type are at the surface. Not only this, but in Hardin county, Illinois, Worthen and Englemann† describe a low arch near Elizabeth. Otherwise the greater portion of the original uplift now lies buried beneath the "Eastern Interior Coal Field" and the "Northern Interior Coal Field."

The writer has now pointed out some of the faunal features that distinguish the Dakota and Mississippian seas during the Middle Devonic. The area of these seas, the Cincinnati island, Kankakee peninsula, and the margin of the bordering lands are in a general way shown on the accompanying maps. It has also been shown that the Dakota and Mississippian seas intermingled to some extent while the intermigration of species is believed to have been most decided during the Upper Devonic. The migrants appear to have traveled from Iowa into New York along the southern shore of Laurentia. This is the generally accepted view and it has much to recommend its acceptance, but that the decidedly European facies of the Naples fauna in the Upper Devonic of New York also came along the same shore as stated by Clarke, the writer cannot believe.

* *Fifteenth Rep. Geol. Surv. Indiana*, 1886, p. 228. ORTON, *Eighteenth Ann. Rep U. S. Geol. Surv.*, 1889, p. 580; KINDLE, *Amer. Jour. Sci.*, June, 1903, pp. 461, 463

† *Geol. Surv Ill.*, I, 1866, p. 352.

‡ *N. Y. State Museum, Rep. State Pal.*, 1902, p. 670.

There is very little in the known fauna of the Dakota sea out of which that fauna could have developed. Ulrich and Schuchert* therefore sought to bring this Atlantic fauna into the Mississippian sea in the region of the Delaware and Chesapeake bays. This view is not known to be, so far as it concerns pre-Helderbergian time, without support as Willis† has shown that during much of Devonic time there existed here the "Appalachian Highlands." Much information has accumulated since our view was expressed showing that many Atlantic invasions occurred during the Paleozoic and as late as the close of the Devonic. We are forced therefore to continue the search for the place of communication of the Mississippian sea with the North Atlantic and Europe. Apparently the only place for communication was to the north of Appalachia and in the region of the Catskill mountains where Devonic strata are now piled 4000 feet above sea level. Projecting these strata across the Hudson Valley and Taconic mountains it is not more than sixty miles to the "Connecticut Valley Trough" of Dana On the basis of paleontologic evidence there are now recognized in this trough, strata of Niagaran, Esopus, Onondaga and Upper Devonic age.‡ Regarding this and other New England troughs Dana§ writes:

"The Acadian and the Gaspe-Worcester tronghs were sinking and receiving in some parts, if not generally, formation after formation, to the close of the Carboniferous period; and the Connecticut valley trough, to the middle or latter part of the Devonian era."

The formations in the Connecticut trough are of great thickness and as the Devonic fossils (certainly those of the Onondaga) are those of New York, it is probable that all of the formations of the Catskill mountains above the "Hudson River" are also present in this trough. It seems to be true that all of these strata are now eroded away over the Taconic mountains, and all excepting the Helderbergian and Oriskanian in the Hudson valley. Accepting this as the place of communication between the Mississippian sea and the North Atlantic by way

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* *Rep. N. Y. State Pal.* 1902, pp. 633, 663.

† *Md. Geol. Surv.*, iv, 1902, p. 61, and paleographic map, pl. V.

‡ EMERSON, *Mon. U. S. Geol. Surv.*, xxix, 1898, pp. 17, 259. ELLS, *Am. Rep. Geol. Surv. Canada*, 1887-8, pp. 9k-11k. Esopus black shale with Caudagalli occurs at Sargent's bay, Lake Memphremagog according to Ami.

§ DANA, *Man. Geol.*, 4th ed., 1896, p. 715.

of the Connecticut trough and the Gulf of St. Lawrence, we can explain the make-up of the Mississippian faunas beginning with the Schoharie and closing with the Chemung. Through this same opening also came the Helderbergian and Oriskanian North Atlantic invasions of the Cumberland mediterranean of Ulrich and Schuchert.

The southern portion of the Indiana basin also was open during Onondaga, Hamilton and Genesee time, establishing communication between the Mississippian sea and Brazil.* Evidence of this is seen not only in the very similar faunas of the Hamilton of the Misissippian sea and that of the Ereré formation of the State of Para described by Rathbun and Clarke† but further in the Louisville phase of the Hamilton of Alabama. It is on Prater's farm, two miles west of Piedmont, Alabama, that Cooper Curtice collected a Hamilton coral fauna with *Spirifer varicosus, Tropidoleptus carinatus,* etc., and the writer found opposite the city of Rome, Georgia, near the northeastern end of Horseshoe Mt. uplift, ostracoda and a few corals at the base of the Chattanooga black shale, indicating the same Hamilton fauna. In neither of these localities is the Onondaga known and it is certain that it does not occur about Rome. However, the Onondaga does occur farther northwest about Pegram, Tennessee,‡ attaining greater thickness in a westerly direction, and is present in considerable thickness near Grand Tower, Jackson county, Illinois.§ As the Oriskany (Camden phase) is also present here with *Amphigenia curta, Anoplia nucleata, Leptocoelia flabellites,* etc.,|| it seems reasonable

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* The writer is not yet certain that the great mediterranean of Neumayr named by SUESS TETHYS was present in Devonic times. However, it seems probable that it was and the Indiana gulf connected with it. For other detail see SUESS, *Nat. Science*, ii, 1893, p. 183 SUESS, *Antlitz der Erde*, iii, pt. 1, 1901, p. 25. KAYSER, *Lehrbuch der Geol.*, sec. ed., 1902, p. 175. FRECH, *Lethaea Geognostica*, cited above.

† *Archivos do Mus. Nac. Rio Janeiro*, x, 1899. Clarke here states that the Erere fauna is "a miniature of the Hamilton fauna." Associated with the sandstones of Erere are layers of dark shale having a few fossils regarded as the "equivalent of the Genesee shale fauna." Further, the Maecuru group is unmistakably of the facies of the Onondaga having that very diagnostic brachiopod *Amphigenia elongata* besides *Anoplia nucleata, Stropheodonta perplana, Tropidoleptus carinatus* and *Vitulina pustulosa*. Too much value for limited stratigraphic correlation cannot be placed on *T. carinatus* as a single example has recently been found in the Oriskany of Maryland. Williams reports it from the Chemung so that it is now known to be nearly coextensive with the Devonic.

‡ FOERSTE, *Bull. Geol. Soc. Amer.*, xii, 1901, p. 424-426.

§ WELLER, *Jour. Geol.*, v, 1897, p. 625.

|| MEEK and WORTHEN, *Geol. Surv. Illinois*, i, ii, iii; SAFFORD and SCHUCHERT, *Amer. Sci. Jour.*, vii, 1899, 429-432.

to assume that the Indiana basin was deepest in its western area and was in communication with Brazil during the latter part of the Onondaga, all of Hamilton, and part of Genesee time. This opening did not exist during Oriskanian and Helderbergian time as the deposits of this age do not go north of Jackson county, Illinois. The Camden Oriskany fauna also occurs in the Armuchee chert about Rome, Georgia, and in the Frog mountain sandstone of Cherokee county of northern Alabama.*

At different times Whiteaves† has identified Middle Devonic species, apparently of the Mississippian type, collected by Bell in the country immediately west and south of Hudson and James Bays. These faunal lists led Weller‡ to write, "From the geographic distribution of the Corniferous fauna, it may be suggested that the province in which it originated was situated somewhere in the Arctic regions, and that representatives of it migrated southward both into North America and into Europe." The writer finds a series of opposing facts of so great importance that be believes that Weller's suggestion cannot be accepted as a working hypothesis. These facts are (1) the character of the Hudson's Bay fauna, (2) the distribution of the Devonic north of the United States, and the dispostion of the pre-Cambrian areas in Canada and the Arctic Archipellago. These facts will now be set·forth.

(1) The Hudson's Bay Middle Devonic fauna as listed by Whiteaves shows unmistakably that their age is about that of the Corniferous Onondaga, and that the faunal facies is more that of the Mississippian type than any other known in America. The U. S. National Museum has had since 1864 a representative collection of the Hudson's Bay Devonic collected by J. McKenzie near Moose Factory which is at the mouth of Moose river flowing into James Bay. These fossils show that the horizon and facies is not that of the Stringocephalus zone of western and northwestern Canada. Further, that the fauna is not strictly that of the Mississippian type and this fact will become more prominent when all the Hudson's Bay material

*Hayes, *Rome Folio, U. S. Geol. Sur.* The writer has recently collected these faunas through the assistance of the U. S. Geological Survey.

† *Geol. Surv. Canada*, Rep. Progress for 1875-6, p. 320; *Ibid.* for 1877-8, pp. 5-6; *Ibid.* for 1878-9, p. 51C; *Ibid.* for 1879-80, p. 33A; and *Amer. Assoc. Adv. Sci.*, 1899, pp. 22-23.

‡ *Jour. Geol.*, x, 1902, p. 429.

is restudied in the light of provincial faunas. The National Museum collection has the so-called *Syringopora hisingeri* but when compared with material from eastern Ontario the latter is seen to have the corallites from two to three times more robust. *S. maclurii* appears to be present, also *Favosites hemisphaericus turbinatus* and *Phillipsastraea verneuili. Acervularia davidsoni* in the Mississippian province is always in Hamilton faunas. Other significant Onondaga species of Whiteaves' list are *Romingeria umbellifera* and *Conocardium trigonale.* The fish, *Macropetalichthys sullivanti,* is, in Ohio, a Hamilton fossil. In the National Museum collection there is also a *Spirifer* closely related to *S. grieri,* one of the characteristic species of the Onondaga. However, the eminently diagnostic Onondaga brachiopods as *Spirifer acuminatus, S. gregaria, S. duodenaria, S. raricosta, S. macrothyris, S. manni, S. macer, Meristella nasuta, Pentagonia unisulcata,* and *Amphigenia elongata* are conspicuously absent. From these statements it is seen that while the Hudson's Bay and Mississippian Onondaga faunas have each their own facies, still both are of the faunal type characterizing the "American Province." This similarity of faunal facies probably indicates distinct basins but having intermittent connection. This connection seems to have persisted well into Hamilton time as Bell collected on Moose river *Spirifer mucronatus* which Whiteaves and Ami pronounce to be the variety *thedfordensis.*

(2) If we examine the geological map of the United States by McGee, the "Western Sheet No. 783 of the Dominion of Canada," and Dawson's "Geological map of the northern part of the Dominion of Canada east of the Rocky mountains,"* it is seen that the Hudson's Bay Devonic is separated from the Mississippian sea by a wide territory (exceeding 300 miles) of pre-Cambrian, occupying the greater part of Ontario and Minnesota. These ancient rocks continue on the surface from western Ontario in a northwesterly direction, occupying a vast extent of the districts of Keewatin, Athabasca and Mackenzie, and separating the Eurasiatic or western Devonic of the Dakota sea from that of the Hudson's Bay. The western province in the arctic regions was shut out from the eastern by a belt of pre-Cambrian extending from eastern Mackenzie

* McGee, *Fourteenth Ann. Rep. U. S. Geol. Surv.*, 1894; Dawson, *Ann. Rep. Geol. Nat. Hist. Surv. Canada*, n. ser. ii, 1887, p. 62R.

through Boothia, Prince of Wales Land and North Somerset. Continuing northward we again find pre-Cambrian along the western side of Grinnell Land. All that we know of the Devonic of this eastern Arctic area is the Middle Devonic along the southwestern margin of Hudson's Bay, extending, as stated by Bell, under the waters of the bay and possibly uniting with the outcrop on Southampton Island at the north end of the bay. Then for more than thirteen hundred miles northward the youngest rocks are Siluric until, at Cape Frazer and Cape Leidy (between lat. 80°-81° N., long. 70° W.), an unmistakable Helderbergian fauna was collected by Kane. In about the same region at Ravine, Dana bay, occur other Devonic fossils recalling rather the Oriskanian than the Middle Devonic. West of Boothia for seven hundred miles no Devonic is known until in the region of Cape Parry and Baring Island in Prince of Wales Strait. These deposits in all probability belong with the Eurasiatic fauna and are the northern limits of the formations in the Mackenzie valley and the Arctic coast of Alaska.

The writer will add here that, according to Suess, Davis strait did not originate until Cretaceous time. During much of, if not all of Paleozoic time, Laurentia was connected with Atlantis* and together they embraced what is now Quebec, Ungava, Labrador, Baffin Land, Davis Strait and Greenland.

It now devolves on the writer to point out the probable path of migration of the Middle Devonic into the Hudson Bay country. It has been stated in previous pages that the Mississippian sea was in communication with a southern ocean extending into Brazil and that the Middle Devonic of the two very widely separated areas has an identical faunal facies. Further, it was stated that in the Connecticut trough about Lake Memphremagog there is an unmistakable Onondaga fauna. The truth of the latter statement is proved by such species as *Syringopora hisingeri, Cladopora labiosa, Stropheodonta inequiradiata, S. perplana, Atrypa reticularis, A. spinosa* and *Conocardium cuneus trigonale,* which occurred in a collection made at Owl's Head by C. H. Hitchcock and recently determined for him by the writer. In Quebec on the Chaudiere, midway between Famine river and the village of

* SUESS, *Antlitz der Erde*, ii, 1888.

St. George, Ells* reports among others the following: *Syringopora hisingeri, Diphyphyllum arundinaceum, Heliophyllum oneidaense, Spirifer* cfr. *duodenarius, S. gregarius, S. acuminatus, Leptocoelia flabellites* and *Schizophoria striatula.* This enumeration shows that the Onondaga of the Connecticut trough is identical with that of New York. It is also known that the Mississippian Onondaga has considerable in common with North Europe and the two regions were undoubtedly in communication. The path was along the shores of the great North Atlantic continent (Atlantis) to the north of Appalachia and down the Gulf of St. Lawrence through the Connecticut straits into the Mississippian sea. This seems to be plain enough but to find the Onondaga path into the Hudson's Bay is not so easy. It is known that about Montreal there were rocks of Onondaga age because in the agglomerate of St. Helen's Island occur *Dalmanella planiconvexa?, Spirifer macer* and *spirifer* cf.—*granulosus.*† However, it does not seem probable that these rocks extended up the Ottawa basin from the St. Lawrence but rather from the Lake Huron region, where the Middle Devonic formations are about 1000 feet thick, eastward through Georgian Bay, the French river in the northwestern part of the Ottawa basin, Lake Temiscaming, Lake Abitibi, and thence northwestward into the Moose river region of James Bay. There are outliers of the Niagaran in the Lake Temiscaming region, having the same fauna as that of the Manitoulin islands, and it seems natural to follow the Devonic along the nearest outcrops of the Siluric.

There is not the slightest evidence to connect the Hudson's Bay Devonic area with that of the Dakota sea, and the same is true in our endeavors to connect the last named sea with the Mississippian sea previous to Hamilton time. The Onondaga fauna is the outgrowth of the Oriskanian fauna of the North Atlantic type plus the migration during Onondaga time of other North Atlantic forms by way of the Connecticut trough and invasions from the far south through the Indiana basin. The Hamilton fauna is the descendant of that of the Onondaga plus north European migrants by way of the Con-

* *Geol. Surv. Canada*, Rep. for 1887-8, pt. K, 1889, pp. 9K-11K.

* SCHUCHERT, AMER. GEOL., April, 1901, pp. 251-2.

TABLE OF WIDELY DISTRIBUTED AMERICAN MIDDLE DEVONIC CORALS.

O, Onondaga.

G, Onondaga drift.

H, Hamilton.

	MISSISSIPPIAN SEA.								DAKOTA SEA.		
	N. Y. Onondaga.	N. Y. Hamilton.	Pt. Colborne.	Ohio, Columbus.	Louisville.	Thedford.	Thunder Bay.	Mackinac.	Traverse Bay.	Milwaukee.	Iowa.
Acervularia davidsoni Milne-Edwards				H	H	H	H		X		X
" " *profunda* Hall				H		H	H				X
Acrophyllum oneidaense (Billings)			O		O			O			
Alveolites cryptodens Billings			O		O			O			
" *goldfussi* Billings					H	H	H			X	X
" *minima* Davis					O						
" *roemeri* Billings			O		O	H		G			
" *squamosus* Billings			O	O	O			G			
Amplexus yandelli Milne-Edwards			O		O			G			X
Aulocophyllum sulcatum d'Orbigny				O	O						X
Aulopora annectans Clarke (N. Y. in Genesee)										X	
" *erecta* Rominger							H			X	
" *serpens* Goldfuss		H			O	H	H		X	X	
Blothrophyllum approximatum Nicholson			O		H						
" *decorticatum* Billings			O		O			G			
Chonophyllum magnificum Billings			O		O			O			
" *ponderosum* Billings							H		X		
Cladopora alpenensis Rominger					O-H		H				
" *imbricata* Rominger					O			G			
" *labiosa* Billings			O		O-H			G			
" *lichenoides* Rominger			O		O			G			

TABLE OF WIDELY DISTRIBUTED AMERICAN MIDDLE DEVONIC CORALS.—Continued.

O, Onondaga.
G, Onondaga drift.
H, Hamilton.

		MISSISSIPPIAN SEA.							DAKOTA SEA.		
	N. Y. Onondaga.	N. Y. Hamilton.	Pt. Colborne.	Ohio Columbus.	Louisville.	Thedford.	Thunder Bay.	Mackinac.	Traverse Bay.	Milwaukee.	Iowa.
Cladopora pinguis Rominger					O-H			G			
" *pulchra* Rominger			O		O			G			
" *robusta* Rominger					O		H	G			
" *rimosa* Rominger					H			G			
" *turgida* Rominger			O		O			O			
Clisiophyllum conigerum (Rominger)					O			O			
Crepidophyllum archiaci Billings					H	H	H	O			
Cyathophyllum conatum Hall		H				H					X
" *houghtoni* Rominger		H					H		X		
" *robustum* Hall		H		O	O	H					
" *rugosum* Milne-Edwards					H			O			
" *validum* Hall	O				O						
" *zenkeri* Billings			O			H					
Cystiphyllum aggregatum Billings			O				H				
" *americanum* Milne-Edwards	O	H	O	O-H	O-H	H	H	O			X
" *conifollis* Hall		H				H					
" *grande* Billings			O		O						
" *ohioense* Nicholson				O-H	H						
" *sulcatum* Billings			O		O			O			
" *vesiculosum* Goldfuss			O		O	H					
Dendropora alternans Rominger					H		H				

Dendropora neglecta **Rominger**			O		H			G			
" ***proboscidalis*** Rominger					O		H				
Diphyphyllum arundinaceum Billings			O		O						
" ***colligatum*** **(Billings)**			O		O			O			
gigas Rominger					H			G			
" ***panicum*** **(Winchell)**					H				X		
" ***simcoense*** Billings			O	O	O			O			
" ***strictum*** Edwards & Haime			O	O	H	H					
" *verneuilanum* (Edwards & Haime)			O	O	H			G			
Favosities alpenensis Winchell (also Manitoba)						H	H		X		X
" *arbuscula* Hall		H				H					
" *billingsi* Rominger		H				H					
" *canadensis* (Billings)	O		O		O			O			
" *clausus* Rominger					O	H	H	G			
" *digitatus* Rominger					H	H	H		X		
" *dumosus* Winchell							H				X
" *emmonsi* Rominger	O		O	O-H	O			O			X
" *epidermatus* Rominger	O		O		O			O			
" *hemisphericus* Troost	O		O	O-H	O-H		H				
" *intertextus* Rominger					O			O			
" *limitaris* Rominger		H		O			H	O			
" *nitellus* Winchell							H		X		
" *placenta* Rominger		H			H	H	H		X		X
" *radiatus* Rominger		H			X		H				
" *radiciformis* Rominger					O	H	O				
" *tuberosus* Rominger	O		O		O-H			G			
" *turbinatus* Billings	O	H	O	O-H	H	H					
" *winchelli* Rominger		H			O		H	G			
Hadrophyllum orbignyi Edwards & Haime				O-H	H						
Heliophyllum exiguum Billings			O			H					
" *halli* Milne-Edwards		H	O	O	O-H	H	H			X	X
" *juvenis* (Rominger)					H	H	H		X		
Heterophrentis prolifica (Billings			O	O-H	H	H		O			
Michelinia convexa d'Orbigny			O	O	X			G			

TABLE OF WIDELY DISTRIBUTED AMERICAN MIDDLE DEVONIC CORALS.—Continued.

O, Onondaga.
G, Onondaga drift.
H, Hamilton.

	MISSISSIPPIAN SEA.								DAKOTA SEA.		
	N. Y. Onondaga.	N. Y. Hamilton.	Pt. Colborne.	Ohio, Columbus.	Louisville.	Thedford.	Thunder Bay.	Mackinac.	Traverse Bay	Milwaukee.	Iowa.
Michelinia clappi (Milne-Edwards)		O			X			G			
" *cylindrica* Milne-Edwards				O	X			G			
" *favositoidea* Billings			O		H			G			
" *insignis* Rominger		H			H		H				
Microcyclus discus Meek & Worthen (also Ill.)						H					
Pachypora fischeri (Billings)			O		O	H	H				
" *frondosa* Nicholson			O		O	H					
Phillipsastraea gigas Owen			O	H	H			O			
" *verneuilli* Milne-Edwards			O			H		G			
Pleurodictyum americanum Roemer		H			H		H				
" *styloporum* (Eaton)		H			H		H				
Romingeria cornuta (Billings)			O	O	H	H					
" *umbellifera* (Billings)			O		O			G			
Striatopora cavernosa Rominger			O		O			G			
" *linnaeana* Billings					X	H	H				
" *iowensis* (Owen)							H				X
Strombodes alpenensis Rominger							H				
" *knotti* Davis					X						
Syringopora hisingeri Billings			O	O	O			G			
" *maclurii* Billings			O					G			
" *nobilis* Billings			O			H	H	G		X	X

	N. Y. Onondaga.	N. Y. Hamilton.	Pt. Colborne.	Ohio, Columbus.	Louisville.	Thedford.	Thunder Bay.	Mackinac.	Traverse Bay	Milwaukee.	Iowa.
Syringopora perelegans Billings			O		O			O			
" *tabulata* Milne-Edwards				O	H						
Thecia ramosa Rominger					O			O			
Trachypora elegantula (Billings)		H		O-H	H	H	H				
" *ornata* (Rominger)		H			H	H	H				
Zaphrentis cornicula Milne-Edwards	O		O	O-H	H	H		G			
" *exigua* Billings			O		O		H	O			
" *gigantea* Lesueur		H	O	O	O			O			X
" *nodulosa* Rominger			O		O			G			
" *scyphus* Rominger					H		H				
" *ungula* Rominger					O			G			

SUMMARY OF THE PREVIOUS TABLE.

The numbers in bold-face are total species at that locality having geographic distribution.	N. Y. Onondaga.	N. Y. Hamilton.	Pt. Colborne.	Ohio, Columbus.	Louisville.	Thedford.	Thunder Bay.	Mackinac.	Traverse Bay	Milwaukee.	Iowa.
New York Onondaga has in common with	**9**	2	9	5	10	3	2	8	0	0	1
" Hamilton " " " "	2	**21**	3	6	9	11	10	1	3	2	3
Port Colborne Onondaga has in common with	9	1	**51**	15	43	15	8	37	0	2	6
Thedford Hamilton " " " "	3	11	15	9	22	**34**	15	8	6	3	7
Ohio Middle Devonic " " " "	5	6	15	**26**	18	9	4	10	0	1	4
Louisville Middle Devonic has in common with	10	9	43	18	**84**	22	26	46	6	3	11
Thunder Bay Traverse has in common with	2	10	8	4	26	15	**38**	10	9	4	9
Traverse Bay " " " " "	0	3	0	0	6	6	9	0	**10**	1	3
Mackinac Onondaga " " " "	8	1	37	10	46	8	10	**53**	0	1	5
Milwaukee Middle Devonic has in common with	0	2	2	1	3	3	4	1	1	**5**	2
Iowa Middle Devonic has in common with	1	3	6	4	11	7	9	3	5	2	**15**

necticut trough, South American arrivals by way of the Indiana basin, and slight invasions from the Dakota sea by way of Traverse straits. These three openings then remained in existence during the greater part of Upper Devonic time.

Postscript.—Since the above was set up by the printer an important paper by H. S. Williams* has appeared. In this work the "shifting of faunas" is discussed. In the main the author restricts his studies to New York and Pennsylvania. His correlations and derivation of the Devonic faunas are not at variance with those of the present writer.

THE DELTA-PLAIN AT ANDOVER, MASS.

By F. S. MILLS, Andover, Mass.†

PLATES XXII–XXIV.

The origin and structure of glacio-fluvitile plains, spread over the land in sub-aerial conditions, or formed in temporary lakes of the glacial epoch, have been well studied and fairly comprehended.

The frontal plain and valley train melt into the surrounding surface features, with no distinct external démarkation. In fact, their exact nature as plains would hardly attract attention, except as a matter of geological study. The sandplain, on the contrary, rises with an abruptness above its surroundings, that arrests the attention even of one not interested from the physiographers' standpoint. While it is true that the sandplain is the result of ice streams plus glacial detritus, yet, the external conditions of deposition and the topographic result, are strikingly dissimilar to the other two types. The division line between the topographic forms they have left behind, as witnesses of former conditions, is very distinctly drawn. That such a plain, also, can only be of sub-aqueous deposition gives an individuality to it, not in conformity with the other forms of wash-plains. It would seem almost justifiable to give it an individual classification and not catalogue it with the others.

The application of the term "sand-plain" generically to such sub-aqueous structures, is somewhat misleading. It is a

* The Correlation of geological faunas. A contribution to Devonian paleontology. *Bull. U. S. Geol. Surv.*, No. 210, June, 1903, pp. 1-147.

† The writer is indebted to Prof. R. S. Tarr of Cornell University for advice and suggestions during the work on the Ballardvale delta-plain.

fair inference from the name "sand-plain," for one to suppose that they are composed of assorted sands. In treating this specific subject, students are liable to have in mind only the restricted locality which they describe. While no student in New England would mistrust the significance of the term "sand-plain," nor those in Pennsylvania that of "gravel-plain," such terms are neither descriptive nor accurate for localities where flat stones are one of the most conspicuous features. If we use the word sand correctly as an absolute and not relative term, the application is incongruous. Any specific designation as to texture is too narrow and limited to hold good, except for a given locality. A finical distinction, however, is neither useful nor practicable. A term that is both descriptive and generically true would seem, on the other hand, to be advisable. The important and interesting fact is structure rather than texture. That they were originally sub-aqueous deltas, which, under changed conditions, now assume the form of elevated plains, is the fact worthy of attention and study. If such has been their cycle of evolution they are homologous topographic forms, regardless of texture. For such topographic forms professor Davis long since proposed the name of delta-plain or delta-plateau, instead of sand-plain,* a designation which has also been employed by many others, being both suggestive and descriptive. While such a designation has been advocated for purely topographic reasons, there would seem to be a further plea, as already suggested, on the ground of texture. Differences in the latter may be due to differences in structure and composition to be found in the bed rock over which the ice-cap rode, and from which it largely collected its debris; as well as to the elevation, slope, and general relief of the region in which a given plain may be found. The abrasion and erosion of the hard, deeply bedded geneissic and granitic rocks of New England, were a different task from the corrosion of much jointed, thinly bedded and soft shales, or limestones, of other regions. The residue collected and dispersed, largely in open valleys in New England, where the bulk of dposits is quartz grains, presents a different aspect from the wash plains and delta plains of central New York. In the latter case the valleys are narrow, high walled, with a moderately steep slope,

* *Proc. Boston Soc. Nat. Hist.*, vol. xxv, 1892.

forcing a concentration of energy into the stream, that could easily handle flat pieces of shale, abundantly supplied by its fissility, from eight to twelve inches in diameter. Bedded material of this size occurs partially throughout the overwash, not as iceberg droppings or exceptional phenomena, but as a prevalent and characteristic structural condition.

Delta plains composed largely of sands, with coarser gravels near the head, are of frequent occurrence throughout New England. An excellent and typical illustration of a glacially built delta-plain is found at Andover, Massachusetts, twenty-three miles north of Boston. [Plate XXII.] The plain itself lies in the southern portion of the town, known as Ballardvale. There extends from New Hampshire across the northeastern corner of Massachusetts into Essex county, a well defined esker ridge. It crosses the Merrimac river northwest of the city of Lawrence, and winds its way into the westerly part of Andover, extending in a general southeasterly direction, to the Shawsheen river. At the river it turns rather abruptly to the south continuing along the west side of the stream. This esker, as it approaches the Shawsheen river, divides into several branches locally known as the "Indian Ridges." These ridges are remarkable in development and structure, and for the present state of preservation. They have long attracted the attention and study of geologists. Their structure, and correlation to the surrounding topography, has been, and is today, a debatable question. The main elevation divides and sub-divides, until it becomes a mass of reticulated ridges inclosing all kinds of depressions, bogs, and kettle-holes. Approximately at the point of primary division in the main ridge, there was a branch crossing to the easterly side of the present Shawsheen valley. The immediate point of connection with the main ridge is slightly obscure, and has been more or less obliterated by the erosion of the present stream. This branch from the main esker, its subsequent course and its termination, have been generally overlooked by those studying the region. Crossing to the easterly side of the stream, one comes abruptly upon the truncated portion of a well defined esker ridge. Its esker character, strictly speaking, is not long preserved. It bears to the east in a meandering course, advancing somewhat up the gentle slope of the valley wall. Within an eighth of a mile it has

Plates XXII and XXIII are to be substituted for plates of the same number in the September issue.

View along the north or ice-contact side of delta-plain; feeding esker on the extreme right.

FIG. A.—Current, or Cross-bedded Sands.

FIG. B.—Coarse and Round Pebbles Imbedded in Sands.

lost its closely definitive form as an esker, and broadens out into a confused, hummocky, kame-like area, as it finally bears to the south. A distant view of it presents the landscape of a morainic region. In passing directly over this area, however, one can trace the indefinite preservation of an esker-like character. The width of this region is approximately a quarter of a mile. It is a complex mass of loosely bedded gravel knobs; reticulated ridges enclosing small kettles; conical, kame-like cones of gravels and sands, and irregular hummocks;—all of water assorted materials. At times, pockets and lenses of the finest sands occur. Exposures of the latter often show marvelous examples of cross-bedding, indicating indeterminate conditions that could produce such an abnormal succession of cross and counter currents. [Pl. XXIII A.] In other places, sections show a contortion, or forcible thrusting of one stratification into another, subsequent to their deposition. The latter is probably due to some minor movement of the immediately adjacent ice. A transverse cut through the ridge, near the northerly end of this complex area, gives an interesting exposure. The body of the deposition is thinly stratified, fine sands. Lying unconformably upon the western side of the sand beds and embedded in it, is a zone of coarse and rounded pebbles. The contact line of the sands and pebbles is suggestive of an eroded channel, or the rounded bottom of a pot-hole. The extent of this coarse deposit cannot be accurately determined, but is probably very limited. A crosscut a hundred feet farther south shows no indication of it. Its localized extent along a north and south axis suggests the work of a moulin, or of a stream descending through a crevasse. [Pl. XXIII, B.] An overburdened stream of a glacial mill might churn out an excavation and leave behind its denser material, not having the power to carry it out of its previously eroded pot-hole. A forward movement of the ice, or a closing of the crevasse would permit such conditions to exist only temporarily. Former conditions would be restored, so that the pot-hole and its contents would be entirely enclosed in the normal deposition of the sub-glacial stream. In fine, that such a complex area as a whole, closely in relation to the dying ice-front, was the result of deposition under a countless variety of conditions, and where shifting changes were rapidly and forcibly accom-

plished is the only conclusion that can be drawn. Stone* applies the aptly chosen term of "plexus" to such areas, and characterizes them as follows: they are "the most remarkable of all deposits left by glacial rivers . . . . its surface covered with a jumble of heaps, mounds, cones, and ridges inclosing all forms of hollows, funnels, hopper-holes, kettle-holes, basins and Roman theatres, many of which are so deep as to inclose lakelets without visible outlet." Such a characterization, though slightly too comprehensive for the region under consideration, yet, is an accurate picture of what might obtain under magnified conditions. The Andover "plexus" is elliptical in shape, narrowing somewhat toward the southern end where it again assumes a more typical esker character, and a closely defined one. Immediately north of the delta plain and to the west, the feeding esker rises in elevation, broadens a little, and merges itself into the level topped surface of the plain. The plain itself is about three-quarters of a mile in diameter from north to south, and a trifle less from east to west. The immediate union of plain and esker, as before stated, is marked by a broadening of the latter, and a sharp rise in elevation. In this amplified area are a number of small pits, depressions, and kettles, from some of which there extend subsequent drainage lines. The portion of the feeding esker leading up to the plain, is very well defined for several hundred feet northward. At this point it has been bisected by subsidiary stream channels of the present Shawsheen river. Isolated sections of this esker are found at intervening intervals indirectly connecting the "plexus" area and the plain. During high water stages of the present stream they look like islands in a net-work of sluggish stream channels, which further on find their way back to the main course of the river. The Shawsheen river washes the base of the esker on the western slope. To the northeast of the area containing the disconnected sections of the feeding esker, there is a glacial lakelet. This lakelet (Pomps pond) is a permanent pond established in an ice-block hole. The water line in the gravels maintains its supply, and during high water in the river, is more or less directly connected with it.

The surface of the plain shows a gently dipping horizon to the south. Its highest elevation is to the north, where the

* *U. S. G. S. Monograph* 34, 1899.

feeding esker merges into the plain. The periphery of the plain is sharply and distinctly preserved, in its nearly circular outline. Those delta plains whose outlines are so distinctly circular, and whose feeding eskers merge uninterruptedly into the head of the plain, have been given the more definitive name of esker "fan."* The converging radii of the plain representing the fan, and the feeding esker the handle. The deposition of the plain took place in a small amphitheatre walled in to the east, south, and west, by low-lying granite hills. While to the north, the temporary lake was held up by the ice-front itself, completing the basin. Along the northern border of the plain, or ice-contact side, the outline in detail is exceedingly cuspate, showing the normal irregularity of melting along the decaying ice-front.

The basin was about one mile and a half in length, from the ice-contact phase to the opposing upland on the south, and in width, from east to west, approximately one mile. In the southern upland border of this glacial lake, is a notch-like opening. Through this notch the lake probably found its first overflow. The drainage led away to the south, and eventually into the Atlantic. When the time arrived that the ice had entirely disappeared from the head of the Shawsheen valley, a reversal of drainage took place. Then the pent up waters would find an easier way of escape to the north, and could empty into the larger valley of the Merrimac, and the lake was rapidly drained. This notch in the southern upland has been greatly deepened by post-glacial erosion of a north flowing stream.

At the head of the delta plain, where esker and plain unite, a compact, stratified deposit of gravel is found. The debris laden stream, issuing from the ice-front into a zone of static water, found its velocity at once checked. With a checking of velocity is found its corollary in a loss of carrying power. Shorn of its initial transporting power, the stream became at once unable to carry further its burden and must perforce deposit some of its load. Such being the fact it would naturally drop first that which was the most difficult to handle; namely, the coarser and denser material. As the velocity, or transporting power, stands in a ratio to distance from point of issuance from the ice-tunnel, so, we find a relative decrease in size of

* *Bull. Essex Inst.*, vol. xxxix, 1897. J. B. WOODWORTH.

sediment in proceeding from the head of the plain to the frontal margin. To the latter point only the finest sands and clay could be transported. There the sediment would assume a steep inclination in the force-set beds. The frontal pitch of the Ballardvale plain is admirably preserved, composed of thinly bedded, fine sands, with a dip of about thirty degrees to the south.

Overlying the delta as a whole, is a thin layer of coarse sediment. As the delta building progressed and the debouching stream assorted its burden the plain structure grew laterally as well as longitudinally. The lateral expansion, or lobes, show a finer deposition than the center. They were out of the main current, and transportation to them of aught but finer sediment was unlikely. As the plain developed vertically, the head slightly in advance of the frontal portion, it became necessary for the stream current to ascend its previous deposition. Toward the latter stages of the delta building, when the surface of the delta approximated the water level, and slightly exceeded it at the head, then the current of the feeding stream must have been forced to make a sharp ascent to reach the horizontal surface of the delta. Some deposition was constantly taking place at the point of ascent, the effect of which was to produce the obliquely inclined series of back set beds.

Owing to a lack of cuts and exposures, this series of beds is poorly shown in the Ballardvale plain. Enough can be seen to be satisfied that such structure exists, though its limitations cannot be satisfactorily determined. That they form, in themselves, an inconsiderable and very minor portion of the plain structure is more than probable. The ratio of forward growth to the deposition of back set beds has been estimated to be about forty to one. This would give, theoretically, a width of back set beds in the Ballardvale plain of about one hundred feet. From a study of back set beds in other delta plains, the proposition that they are formed by a down sliding of material upon withdrawal of the ice-contact, seems untenable. There is every indication in texture, homogeneity of structure, and surroundings, to prove that they are the constructive result of an upcurrent stream.

Numerous cuts made by temporary, wet weather streams, down the northern face of the delta-plain reveal a quasi- stratification, formed by the downward gravitation of sediments al-

FIG. A.—Back-set Bedding in Delta-Plain.

FIG. B.—Truncation of underlying Strata by those superimposed, in the Process of Down-Sliding.

ready assorted by water. Such a condition has been produced experimentally by the writer, and while furnishing no conclusive proof its evidence tended to corroborate the facts found in nature. Stratification formed by downsliding of material has none of the compactness and continuity apparent in that formed by the agency of an upward stream current, as exhibited in the true back-set beds. There is a constant tendency, in the downward gravitation of material, for the superimposed strata to truncate the ends of the laminæ lying immediately underneath; a condition that is perfectly in accord with the laws of gravity. The distinction in bedding is not seen by a casual glance, but careful investigation with freshly made and satisfactory located exposures seldom fails to demonstrate the fact. If on the northerly side of a delta-plain exposures are made by a saggital cut at the juncture of feeding esker and plain, and a similar cut is made at some distance in the ice contact phase of the plain, the difference in bedding and nature of stratification is clearly shown. [Plate XXIV, A and B.]

When the delta had reached that point of maturity at which the ice-stream could no longer continue aggrading, it became a destructive agent instead of a constructive one. The stream had thrust upon it the necessity of channeling its own delta. Two of such drainage creases have left their marks across the Ballardvale plain. One is traceable from the south-eastern frontal margin well back toward the head of the plain. The other though larger and better developed at its mouth, on its southwest margin, does not appear to have eroded so far back toward the head of the plain, or was subsequently filled up. During the entire period of delta construction the greater velocity and stream currents probably had a decided trend to the southeast, for the plain here reaches its greatest extent longitudinally. The exit of these two drainage lines from the present plain into the former lake basin, gives a tri-lobed outline to the plain.

It is evident that if the delta plain building was cotemporary with the final stages of ice-retreat, that the ice-front must have been in a more or less unstable condition. From the decaying ice-margin would be constantly detached crumbling blocks or isolated bergs, some of which, rafted out over the plain, may have melted and dropped their heterogeneous load

of debris promiscuously about the delta plain. Such inharmonious deposits may be found at any stage of the delta building. Other blocks of ice may have grounded and become fixed in the growing deposit of the delta. The resting sites of several presumable ice-blocks are marked by kettle-holes in the Ballardvale plain. One of good size near the northeastern margin, and a smaller one near the centre, are splendidly preserved and very typical. No drainage crease appears at the surface in connection with either of them. Probably the ice-blocks did not attain any great hight above the level of the delta, and the sub-drainage was sufficient to take care of the melting ice.

The nature of the immediate region and the surrounding topography would indicate that the delta was rapidly constructed. The appearance of the esker, and "plexus" area to the north, the immense amount of comminuted debris, the comparatively short time during which the ice-front could hold up a lake in this region, the assumed physical condition of the ice at the time, all point to a short duration for the delta construction possibly a single season.

The Ballardvale delta plain, though not very extensive, is beautifully developed, and is an admirable type of those delta plains formed in a temporary lake of the glacial epoch.

AGE OF THE LAVAS OF THE PLATEAU REGION.

By Albert B. Reagan.

INTRODUCTION.

Within the Plateau region in the rectangle bounded by parallels 32° 45′ and 34° 20′ and the meridians 107° 30′ and 110° more than nine tenths of the surface is of volcanic material. From this main body there stretches two main arms; one going northwest, eighty miles to Mount Taylor, and the other west-northwest, one hundred and seventy-five miles, to the San

Francisco group of volcanoes. The total area of the lava flows of this region in Arizona is about 25,000 square miles, or about half that of New York state.

But this superficial lava sheet is only one of the great lava sheets that have overspread the region. It was preceded by two great lava flows, the lavas of which have been almost obliterated by erosion. The earliest of these flows is now represented only by volcanic necks and laccolites. The next earliest flows were fissure and volcanic eruptions, the lavas of which crest or flank many of the mountains of the area. The remainder of the sheet then outpoured is entirely removed.

The lavas which were ejected in this district are (1) the basalts, including the sanidin-dolorite types; and (2) the trachyte-rhyolyte lavas. The former were ejected last; at least, they are the predominating lavas of the last volcanic disturbances. The latter were the predominating lavas of the fissure eruptions, and most probably of the earliest eruptions also, though propylyte and andesyte seems to have been also ejected.

LITERATURE.

Dr. C. L. Herrick examined a part of the lava field included within the Rio Grande valley, and in speaking of its age, he says that the group of cones from which the lavas west of Albuquerque were outpoured is only one of a series of basaltic post-tertiary volcanoes, which can be traced along the entire length of the Rio Grande in New Mexico. And furthermore, the age of their lavas may be placed at an earlier age than that in which the river gravels were deposited, that is, earlier than the post-glacial or Champlain epoch (Bull. of the Univ. of New Mexico; "Environs of Albuquerque," p. 38; and "Papers on the Geology of New Mexico," p. 94.)

The writer found basalt as an agglomerate stratum in the Pleistocene at Vallecieto Viejo, New Mexico. He also found while digging a well at Jemez in the same territory that the conglomerate stratum, underlying the Pleistocene was mostly composed of vesicular basalt. (February No. of AMERICAN GEOLOGIST, for 1903, pp. 87-88.)

Mr. Marvine, who made a geological trip from Camp Verde in Arizona to the Gila river, found basaltic lava underlying the alluvium of the San Carlos valley (U. S. Geographical Surveys west of the 100th Meridian, Vol. III, p. 221).

Professor G. K. Gilbert in his report on lake Bonneville (House Miscellaneous Documents, 1889-90, Vol. 17, p. 336) says:—

I have seen in Utah, Idaho, Nevada, California, Arizona, and New Mexico about two hundred fields of lava, judged by their color and habit to be basaltic, and as many as three hundred and forty cones of basaltic scoriæ.... of the streams and fields, 15 per cent. are judged to be Pleistocene; of the cones 60 per cent. the remainder are judged to be Tertiary."

Again in speaking of the age of the lavas of the west Mr. Gilbert says that the trachytes and rhyolytes rest upon and intersect in dikes, all the sedimentary rocks from the Archæan to the Tertiary, and they were seen to underlie none of these, also that at every point of contact the trachytes and rhyolytes underlie the Bonneville beds. He continues: "The denudation of the trachytes themselves has been great, so great that it is measured by the same order of unit that is applied to the denudation of the sedimentary beds. Not merely is the original surface removed from even the most recent of the trachytes but all craters have been destroyed and cones of mingled tuff and lava, that must have assumed the most imposing proportions, have been reduced to the merest ruins. Great dislocation, as well as denudation has succeeded in places the accumulation of trachytes and rhyolytes, and mineral veins have been formed within them and along their contact planes. Great erosion certainly, and probably dislocation also, of early eruptions have been succeeded by later eruptions, and stand in proof of the great duration of the trachyte epoch."

Professor R. T. Hill says:—"It is evident that eruptive activity has occurred in the Texas-New Mexico region from Cretaceous to present time, and at least three well defined epochs are at present recognizable, viz.:

"1. The Austin-Del Rio system or Shumard knobs; ancient volcanic necks or laccolites bordering the Rio Grande embayment, begun in later Cretaceous time, the lavas of which have been obliterated by erosion.

"2. Lava flows of the Raton system, which are fissure eruptions of Teritary times and which are only partly removed by erosion.

"3. The Cinder cones and lava flows of the Capulin system, which are late Pleistocene and which still maintain their original slope and extent" (Bull. of the University of New Mexico, Vol. I, p. 94-95; also see Bull. Geol. Soc. of America, Vol. III. p. 98).

STRATIGRAPHICAL SECTIONS.

Section 1, in Seven Mile Hill canyon, five miles southeast of Fort Apache, Arizona.

Quaternary:	
1. Basalt	200
2. Volcanic ashes	10
3. Strata of mostly unlithified sands and clays	40
4. Shale, light colored, sandy	4
Tertiary:	
5. Conglomerate rock. The pebbles and cobblestones of this series are: quartzite, granite, andesyte, rhyolyte, limestone of the Palæozoic era, etc. (no cobblestone or pebble of the basaltic type was found in this conglomerate),	60
6. Strata of partly lithified coarse grained, reddish to light brown sandstone, composed of angular and rounded grains of granite, rhyolyte, etc. In this series the rhyolyte-trachyte particles predominate,	200
Carboniferous:	
7. Red gypsiferous shales, with sandstone and limestone	1100
	1614

Section 2, East wall of Cherry creek canyon, Arizona. seven miles north of Salt river near Mr. Jim Hinton's house.

Tertiary:	feet
1. Light brown to dark brown rhyolite, capping buttes. This rhyolyte is continuous at the base of the buttes with that which underlies the tertiary formation here	30
2. Conglomerate rock, the cement being tufa	80
3. Tufa agglomerate	20
4. Light gray sandstone	10
5. Rhyolyte trap	30
6. Gray sandstone and conglomerate	100
7. Fine grained, gray to brown sand stone, composed of ground up archaean and Palæozoic rocks, granite, rhyolites, diabases, etc.	40
Total	210

Section 3. South of White River, three miles west of Ft. Apache.

Quaternary:	
1. Basalt	200
2. Unlithified volcanic ashes	10

The Trachytes and Rhyolytes:—They underlie the Basaltic sheet in many places. They also crest or flank several of the mountains of the region. The entire Jemez Plateau in New Mexico and the Apache and Pinal mountains in Arizona are made up of it. The Rhyolyte of the Jemez plateau does not overlie the Eocene (Upper Cretaceous?), but whether it was poured out in Cretaceous or pre-Cretaceous time, could not be determined by the writer. It was so long ago, however, that the craters and plugs have been mostly reduced to the common level of the country and cease to be observable at all. In the Pinal and Apache mountains in Arizona the Rhyolyte underlies the valley fillings (Pleistocene and Tertiary) and in the Hinton, (Cherry Creek) formation it both underlies the Tertiary and is interstratified with it; but at no place was it found interstratified with or overlying the Bonneville or Quaternary formation. Again, there is evidence that the greater part of the Rhyolyte is far older than the Tertiary and Pleistocene overlying it. Before the deposition of the Tertiary after the eruption, erosive agencies reduced the lavas till only palisade buttes and volcanic cores remained. These project above the deposits to this day; and show conclusively that the sediments were deposited around them as they now stand; all of the strata of the entire region dip in the same direction irrespective of their near proximity to the volcanic cores and buttes. The Trachyte and Rhyolyte lava flows commenced in the late Cretaceous and continued through the Tertiary till near the close of that epoch. Of the first of these flows, nothing remains except volcanic necks and an occasional mountain mass that has withstood the degrading power of erosion, the extended sheets being wholly removed. Of the latter flows, a great part of the lava still remains. The flows were often from fissure vents and their lavas now crest or flank many of the mountains of the region as we previously noticed. The outer limits of the lava sheet, formed at this time, has been removed and the greater part of the now existing sheet is overspread with Basalt where observed. The exception of this rule is in the Apache and Pinal Mountain districts, no Basalt being outpoured there.

The Basalts: The Basalt lavas were observed to overlie the Pliocene and underlie the Pleistocene and Champlain formations along the Rio Grande embayment in New Mexico. They

are interstratified with the Pleistocene at Vallecieto Viejo in the same territory. They form a part of the conglomerate series that underlies the Pleistocene at Jemez, four miles southwest of the last named place. In Arizona, in the middle Cherry Creek valley and in the Tonto basin, they are interstratified with the Pliestocene (Quaternary) and in a few cases are seen to underlie it; and in the Mogollon region, in the White River valleys, in the Sierra Blanco district, and on the Nantanes plateau they overlie the Quaternary, while in the San Francisco volcanic district, which was not visited by the writer, professor Gilbert says that some of the basalts are Post-glacial in age.

The basaltic flows then begun in the Tertiary and continued to the post-glacial.

CONCLUSION.

It is evident that eruptive activity has occured in the Plateau region from Cretaceous to recent time and at least three well-defined epochs are at present recognizable and at least two distinct kinds of lava flows, viz:

1. The ancient volcanic necks and laccolites bordering the Rio Grande embayment and extending west across the Plateau to the Salt River and Gila valleys in Arizona, begun in later Cretaceous time, the lava sheets of which have been removed by erosion, except in the Jemez mountain district.*

2. The Trachyte-Rhyolyte lava flows of Tertiary times, which are mostly pre-pliocene in age, and which are only partly removed by erosion.

3. The Basaltic flows and cinder cones, begun in Tertiary time and continued to the post-glacial epoch, the last flows of which still maintain their original slope and extent.

* The Rhyolyte lavas of this district may prove to be Tertiary in age upon further investigation.

MODERN RATIONAL RELIEF OF THE EARTH'S SURFACE.

Abstract of a paper delivered before the American Association for the Advancement of Science.

By George Carroll Curtis.

The Paris Exposition of 1900 afforded a comparison of the world's work in representing its surface in actual relief. It was evident to the observer that in the broader and more rational methods, the United States fell below some of the countries of Europe in this work. It is the object of this paper to consider some of the possibilities of "relief maps" and to endeavor to point out a course by which American work may be advanced upon more rational lines.

In possessing the third dimension of thickness, the model is lifted beyond the limitations of arbitrary convention, which must ever make the map an artificial means. A perfect relief map would be a perfect miniature or model of nature, and on the scale of nature direct casts might in some instances be taken from the field. Truthful topographic modelling is therefore an exact art requiring accurate, systematic and rational methods throughout, gathering a data upon the field, and its application and reproduction in other dimensions. Modern inventions, including "dry-plate" photography, contour maps and the interpretation of topographic forms, which the late advance in geographic science has given, are potent aids in and largely accountable for the rational development of this most truthful and expressive of known means for representing the configuration of the earth.

There are two methods of representing topography in relief, the mechanical, and the rational or truthful, and they are so distinct in requirements, process, and results, and their demands are so fundamentally different, that they should by rights conflict in no way with each other. If it is desired to make a conventional mechanical "relief" and it is considered worth while and consistent to employ the truthful medium of three dimensions, rather than the uncompromising one of the shaded map, no objection can be reasonably offered, though the naturalist may regard such empirical work as unprogressive. It is when this mechanical construction is made to assume the

purpose and use of the rational model, the representation of the real features of the land in their characteristic expression, that attention should be called to the error.

It is as reasonable to expect satisfactory results from the mechanical models if truth is wanted, as it is, from giving, for example, several contours from a live figure to a mechanic and permitting him with this data alone to attempt to carve out an expressive or "living" statue. This product would stand at the right hight and would be correct according to the data furnished at several levels, but in other respects could one "speaking likeness" be expected? Were the usual methods of constructing mechanical models employed, neither arms, "parts" nor head could be distinguished. If the scale employed were the same throughout, the model would as near resemble a stack of straw as a man, and if the vertical element were exaggerated according to the frequent custom in "reliet maps" thc statue would resemble the flag pole.

The two distinct classes of work have fields of their own, and since the truthful model embodies all the correct data of the mechanical model the two bear the relation of part and whole.

The use of the mechanical corresponds to that of the conventional or exaggerated engineering section or "blackboard diagram" which does not assume to be natural and therefore may not be depended upon except for special purposes. Under the direction of a skilful demonstrator this may convey ideas of relative hights which would not be so apparent on the truthful representation of the facts, or upon the field. It does not burden one with the multiplicity of facts which crowd the landscape, and liberty may be taken with it, from covering over with letters, figures and colors to twisting one of its scales any number of times out of its true form. It has the value of the arbitrary diagram representing graphically some points to be illustrated.

The mechanical model is cheaper since it can be rapidly produced by inexpensive labor while the truthful model requires the direction of a scientist and the skill and appreciation of the landscape sculptor and painter.

One of the purposes of resorting to topographic reliefs is to present to the general public the facts of diction which

only the specialist is able to interpret from the contour map, and to attract wide attention to some specially instructive area by presenting the most expressive illustration possible. Can the mechanical relief map, confessedly conventional, accomplish this end satisfactorily? The fine model of the Jung Frau, which attracted thousands of persons to it daily at the Paris Exposition, made by the modern school of Swiss scientists, is an answer. The Washington city models which since their installation in the Library of Congress last spring, have been daily sought out by a large number of visitors, is another instance of the public appreciation of truthful work in topo-

A Truthful Model of Alphine Peaks made by the Heim School. The accuracy and expressive of this work appeals not only to the naturalist but to the public as well.

graphic models. There were a number of American mechanical models at the Paris Exposition which were scarcely noticed, and there have been similar reliefs in the Congressional Library for a number of years past that seem incapable of obtaining the recognition of the public.

If, then, an important object of the topographic relief is to bring as much public attention as possible to an area where the map is inefficient, the mechanical relief can not by merit take the place of the truthful model. The bringing of topographic data which otherwise must remain as a closed book, to all but

the specialist into a form which is readily grasped by the general public must be considered as very desirable. It means a wider possible field for the distribution of information having, as does the understanding of the relief of our country, a vital value to a large percentage of the population, and the derivation of public benefit from data which having cost the people much, remains in form from which they can derive little immediate personal benefit. It has been suggested by an eminent geologist that in order to bring about this result, the topographical modelling of the United States might be put on a

A Mechanical or Convention "Relief Map" showing excellent "lettering" arbitrary generalities, but little if any characteristic likeness to the actual field represented. Interesting only to specialists.

similar basis as that of other scientific work of the government bureaus.

This better work is being carried on by private institutions and individuals, but being under no obligations to furnish topographic information to the public, the results may not bring immediate general usefulness.

Conclusion.—Mechanical models may consistently embody any liberty of distortion or convention which may be preferred. Rational models are restricted throughout by the facts and laws of nature.

Only by following rational methods, can truthful results be expected in topographic modelling. Data must be gathered in the field under expert direction and be embodied into the work by a scientific system. This requires the supervision of a qualified geographer.

Forms must be characteristically expressed, truthfully rendered and consistently colored. This calls for a specially trained landscape sculptor and colorist.

NEPHELINE SYENITE IN WESTERN ONTARIO.

By Willet G. Miller.

Last summer the writer found several boulders of nepheline syenite, a couple of feet or so in diameter, not far from the east shore of the upper part of Sturgeon lake. This locality, by the canoe route, is about 75 miles northward of Ignace station, on the Canadian Pacific railway. Syenite somewhat similar in character, but in which no nepheline was observed in hand specimens, was seen in place on the shore of what the prospectors call Nine-mile lake, on the route from the northeast arm of Sturgeon lake to Savant lake. This outcrop was not carefully examined. It is extremely likely, however, that the nepheline syenite is in place in the district lying between the two lakes, judging from the character of the outcrop seen, and from the fact that boulders of nepheline-bearing rock are somewhat abundant some miles to the southward.

The interest in the finding of these boulders, 150 miles northwest of Port Arthur, lies in the fact that they show nepheline syenite to exist farther to the northwest than had previously been known to be the case. The occurrences of this rock, which was formerly placed among the rare varieties, in Hastings county and adjoining territory in the most eastern part of the Province, as well as across the Ottawa river in Quebec, at lake Kippewa and other points, and along the north shore of lake Superior in the vicinity of Port Coldwell, have been described in the last three or four volumes of the Bureau of Mines. A unique type of nepheline-holding rock has also been described from the southeastern part of the Rainy River district, by Dr. A. C. Lawson. It is thus

shown that nepheline as a rock constituent occurs widely distributed in the Archæan districts of the Province. These rocks are of ecomonic interest from the fact that the corundum deposits, which have given rise to an important industry in the eastern part of the Province during the last three or four years, belong to the same series.

Hand specimens of the Sturgeon lake boulders show the rock to be light gray in color, and medium to coarse-grained in structure. The minerals that can be made out with the naked eye are feldspar, nepheline, black mica, magnetite, apatite and pyrite.

Feldspar is the most abundant mineral in the rock and appears to be, so far as can be determined without the use of the microscope, all of the alkali variety. Carlsbad twinning is shown by some of the individuals which exhibit a tendency to take on a crystal outline, being set in a ground mass of nepheline.

Nepheline is the most abundant constituent after the feldspar. On a weathered surface, which is, however, not characteristic of all the specimens, the nepheline has become stained a light brown, while the feldspar is to all appearance unaltered. The latter mineral here makes up approximately two-thirds of the mass of the rock, and the former one-third.

Black mica is, after nepheline, present in the greatest proportion. In one specimen there is considerable apatite. This mineral shows a tendency to associate itself with the mica.

The magnetite is present in subordinate amounts. One octahedral crystal, which has a diameter about two-thirds that of a pea, reminds one of the occurrence of this mineral in the nepheline syenite of Hastings county.

One or two cubes of pyrite are present in the specimens. They have diameters of about the same length as that of the magnetite crystal just mentioned.

As is well known, nepheline rocks show a great tendency to exhibit variety of grain and mineralogical composition in comparatively small parts of the same mass, or even in a single hand specimen. It is therefore difficult to give a clear idea of the characteristics of a mass of this rock by describing a few thin sections.

Two small sections of the hand specimens described were examined microscopically by Prof. R. W. Brock, who has kindly furnished me with the following account of them:

"The rock is a hypidiomorphic granular one, consisting essentially of microperthite, microline and hydronephelite, nepheline, with some biotite, amphibole and a little diopside (?). A little magnetite and some calcite secondary after the pyroxene are also present.

"The feldspars which make up the bulk of the rock are hypidiomorphic—some of them show crystal outlines. They have the well-marked cleavage and other characteristics of the alkali feldspars. No lime-soda feldspar was seen.

"Hydronephelite; A clear white mineral in leafy or columnar aggregates filling the interstices between the feldspar crystals. Index of refraction is low, double refraction high. It possesses rude cleavage parallel to the long axis of the columns, and this is the direction of the axis of least elasticity; uniaxial; positive; gelatinizes with acids. It is no doubt an alteration product from nepheline which originally filled the interstices between the feldspars.

"The biotite is the most abundant colored constituent, but is present in only small amount in the sections. It occurs in two forms, in stout thick plates, having a deep brown color scattered through the sections, and in small green scales, giving generally a lath-shaped section showing perfect cleavage. These occur in groups, and do not appear to be altered forms of the brown biotite.

"Amphibole; Several large crystals of a deeply colored bluish green amphibole, somewhat resembling arfvedsonite, occur in the section. They do not show crystal terminations. The pleochroism is strong: $\mathfrak{c}$—deep bluish green, $\mathfrak{b}$—olive green, $\mathfrak{a}$—deep yellowish green. $\mathfrak{c} > \mathfrak{b} > \mathfrak{a}$. The double refraction is low. The extinction is high, $\mathfrak{c}$: c=20°, which differentiates it from arfvedsonite. $\mathfrak{b}$=b, so that the clinopinacoid is the axial plane. It is optically negative—the axial angle appears to be small. It sometimes holds inclusions of brown biotite and is somewhat decomposed. It resembles arfvedsonite in some respects, but the latter has an extinction of $\mathfrak{c}$: c=76°. Hastingsite bears a close resemblance but its extinction is 30°.*

* *Am Jr. Science*, 1896, p. 210.

A very similar amphibole is described by Dr. Wright from an alkali syenite from Beverly, Mass.*

Mr. A. G. Burrows found a specimen taken from one of the boulders to possess the following percentage composition:

SiO_2	55.64
Al_2O_3	19.81
†FeO	3.90
CaO	2.86
MgO	0.95
K_2O	4.60
Na_2O	8.21
P_2O_5	0.103
Moisture	0.35
Loss on ignition	3.14
Total	99.563

Bureau of Mines, Toronto.

EDITORIAL COMMENT.

THE ANTIQUITY OF THE FOSSIL MAN OF LANSING, KANSAS.

The last number of the *American Anthropologist* (for April-June, 1903) contains a paper by Dr. Ales Hrdlicka, of the American Museum of Natural History, New York, on "The Lansing Skeleton," giving in much detail the characters and measurements of the bones, and especially of the skull.

"The skeleton," writes Dr. Hrdlicka, "is distinctly that of a male of about fifty-five years of age. The man was of medium stature (about 1.65 m.) and of ordinary strength. The bones of the lower extremities indicate better development than those of the upper, showing greater relative use of the former. Considered anthropologically, all the parts of the skeleton, and the skull in particular, approach closely, in every character of importance, the average skeleton of the present-day Indian of the Central states. Zoologically, as well as in growth, the Lansing skeleton and the skeleton of the typical present-day Indian of the upper Mississippi region are of the same degree and quality."

* *Tschermak's Min. Mit.*, Band xix, Heft. 4.

† All the iron is estimated as FeO.

Farther on, in the conclusion of the paper, the author says of this skeleton: "Any assumption that it is thousands of years old would carry with it not only the comparatively easily accepted assumption of so early an existence of man on this continent, but also the very far-reaching and far more difficult conclusion that this man was physically identical with the Indian of the present time, and that his physical characteristics during all the thousands of years assumed to have passed have undergone absolutely no important modification."

It may be answered that all the Pleistocene fauna and flora, driven southward by the accumulation of the continental ice-sheet and returning as the ice retreated, comprised the same species, with similar geographic range, as now. During the long Tertiary era, the proportion of species that are still living had gradually increased, until at the beginning of Quaternary or Pleistocene time probably all the present species had come into existence. They also had doubtless nearly the same range from east to west as now, some species and varieties being limited to the Atlantic coast, others to the Mississippi basin or the western plains, while the Cordilleran belt and the Pacific coast had each likewise its peculiar animals and plants. If men had occupied this continent at some time before the Ice age, as perhaps 100,000 years ago, the general physical characteristics of the tribes in the different parts of America may have become developed before the Iowan stage of the Glacial period, estimated 12,000 to 15,000 years ago, to essentially the same condition as at present, so that the people of the Missouri and Mississippi region then resembled very nearly the tribes now or recently living there.

The most ancient pictures found in Egypt, belonging to a time about half so long ago, prove that then the same physical differences existed between the Egyptian people and the negro and Assyrian peoples, on either side, as have since persisted through thousands of years.

Whether the Lansing man lived during the decline of the North American ice-sheet or at some later time, as possibly only a third or a tenth so long ago, must be determined by the geologic deposits inclosing and overlying his skeleton. These seem to the present writer to belong to the Iowan stage of glaciation, consisting chiefly of an original deposit of loess. In

numerous other localities, as at Muscatine and Council Bluffs, Iowa, and Clayton, Mo., near the city of St. Louis, stone arrowheads, spear points, and axes, have been found in or beneath the loess, denoting nearly the same degree of skill in making stone implements at the time of deposition of the loess as when this region was first reached by Europeans. A like conclusion for the long antiquity of man in the central part of Kansas is also required by the discovery reported by Williston, near the Smoky Hill river in Logan county, of an arrowhead with and beneath bones of an extinct species of bison, overlain by twenty feet of the plains marl. Thus abundant geologic testimony that man was in Kansas and adjoining states during the chief epoch or stage of the loess deposition should surely outweigh any supposed objection derived from the similarity of the Lansing fossil man to the present Indians. W. U.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Report on the Mineral Resources of Cuba in 1901. Prepared by HARRIET CONNOR BROWN, of the Division of Mining and Mineral Resources, under the direction of Dr. David T. Day, of the U. S. Geol. Survey, for Brig. Gen. Leonard Wood, Military Governor of Cuba. Pages 121, with 12 plates (views from photographs). Baltimore, Md., 1902.

This report, forming Part II of Volume V of the Civil Report of Gen. Wood, is based on a geological reconnaissance in May and June, 1902, by Dr. C. Willard Hayes, assisted by T. Wayland Vaughan and Arthur C. Spencer. The value of the production of iron ore in 1901 is stated as $1,240,555, and of all mineral products, $3,279,978.

Asphalt, one of the most interesting products of Cuba, is reported in 20 pages. Its output in 1901 was 4,554 tons, valued at $38,950. True coal is not found, or is very rare, though some of the asphalt deposits resemble bituminous coking coal. W. U.

Washington Geological Survey, Volume II: Annual Report for 1902. HENRY LANDES, State Geologist. Pages xiii, 281; with 23 plates, and 46 figures in the text. 1903.

Reports on the building and ornamental stones of the State of Washington, by Prof. Solon Shedd, and on its coal deposits, by Prof. Landes and C. A. Ruddy, are published in this volume, based on the field work of two years.

Quarries of granite, tufa, basalt, sandstone, marble, and serpentine, are described. Tests of these stones have been made, and are presented in tables, showing their crushing strength, elasticity, specific gravity, effects of freezing and thawing, and chemical analyses.

The coal deposits of Washington, occurring on both sides of the Cascade range, are referred to the early part of Eocene time. During the Miocene and Pliocene orogenic movements that attended and followed the great basalt outflows in the Cascade range and on the Columbia plains, the coal measures in most of their areas were strongly folded and compressed, with frequent faulting; but in the Roslyn area, the most valuable in the state, on the east side of the range, the rocks were only gently folded. The coals range from lignite to bituminous coking coal.

In the year 1902 the production of coal in Washington amounted to 2,690,789 tons, and of coke, 40,569 tons. San Francisco has been the chief market outside the state, with beginning of shipments in 1901 to the Hawaiian islands and Alaska; while about two-thirds of the total production is used in or near the state by railways and steamships, and for domestic purposes, smelting, and manufacturing. W. U.

Preliminary Report on the Lead and Zinc Deposits of Southwestern Wisconsin. By ULYSSES SHERMAN GRANT. Wisconsin Geological and Natural History Survey, Bulletin No. IX. Pages vii, 103; with 4 plates and 8 figures in the text. 1903.

This report concisely describes the geology and ore deposits of the lead and zinc mining region in Wisconsin, which has been more productive than its continuations into Illinois and Iowa, in the vicinity of Galena and Dubuque. A geological map is presented, comprising Grant, Iowa, and Lafayette counties, an area of about 2,500 square miles.

More than two centuries ago, the lead of this region was known to the early French explorers, Perrot and Le Sueur; and it was first mined in 1788 by Julien Dubuque, on the site of the city that bears his name. During the past seventy-five years mining has been carried on continuously; and for about forty years the zinc ores have been worked, their yield becoming larger than that of lead.

Dr. Grant has here well summarized the result of former elaborate surveys and discussions of this important mining district by Strong, Chamberlin, and Van Hise, with aid also from the more recent report by Bain on the similar lead and zinc deposits of the Ozark region. The purpose of this publication is to give a compendious description of the district and its ores, and to explain the processes of their deposition, so that they will be readily understood by those engaged in mining and by investors who may further extend this industry.

It is recommended that a topographic map of the district be made by this Wisconsin Survey on the scale of a mile to an inch, with contour lines for each twenty feet; and that the principal mining localities be mapped more in detail, on the scale of four inches to the mile, with publication on at least half that scale, the topography being shown by contours ten feet apart. On these maps, besides the coloring of the

geologic formations, Dr. Grant advises that the altitude of the base of the Galena limestone, and possibly also of the base of some other formations, as the St. Peter sandstone, should be everywhere approximately indicated.

The geologic series, nearly horizontal in bedding, extends from the Potsdam sandstone upward to the Niagara limestone, which caps a few isolated mounds; and the whole series represents essentially continuous deposition. There is no sure evidence that the district received any rock formations after the Niagara period. During the Ice age it was exempted from glaciation, being a part of the large driftless area of southwestern Wisconsin and the edges of adjoining states. It formed a low peneplain, nearly at the sea level, during Cretaceous or early Tertiary time; but subsequent elevation caused the streams to erode wide valleys 100 to 400 feet, or more, below the uplands. The amount of this erosion is about equal to the masses left between the valleys, so that the general Tertiary denudation thus known averages about 200 feet for the entire district. A considerable amount of earlier denudation is also known to have taken place, for the thickness of residuary soil and clay on the broad upland tracts averages about thirteen feet, which would correspond to a removal of 100 feet or more of the limestone strata.

The ores mined are galena, sphalerite, and smithsonite, occurring chiefly in cracks or crevices of the Galena and Trenton limestones. They also occur in brecciated or very porous parts of the limestones, and as deposits disseminated in some places at and near the junction of these formations. The original ore deposition is attributed to deep-seated or artesian water circulation, supplemented later by the ore-depositing action of the shallow downward circulation of surface waters.

Although the ores near the surface have not yet been exhausted, the future mining development is expected to be mostly at greater depths. Dr. Grant thinks that the lower seventy-five feet of the Galena limestone, with the next few feet at the top of the Trenton limestone, contain larger quantities of zinc ore than have yet been produced in this district. W. U.

Palaeontologische Notizen, 3-6. VON CARL WIMAN. [Bull. Geol. Institut. of Upsala. no. II, Vol. VI, part I, 1902.]

3. *Uber Robergia micropthalmus Lurs. und Triarthrus jemtlandicus, Lurs.*

It is refreshing to be taken back to the times behind Linnaeus for an author who is worthy to have his name perpetuated, not in perennial brass, but in a new generic name for a peculiar trilobite Laurentins Roberg (1715) taught in the university of Upsala before Linnæus. He was a naturalist who gave some attention to fossils and described trilobites as remains of crabs.

This species, *Robergia micropthalmus,* had been described both by Linnarsson and Brögger as a Remopleurides; Holm supposed it similar to *Dicellocephalus serratus,* with an extension of the cheek in front of the glabella, but Wiman found there was no such extension. The

large lobe of the glabella in front of the eyelobe excludes it from Remopleurides.

Triarthrus jemtlandicus is a species with obscure glabella and wedge shaped front to the middle piece of the headshield.

4. *Paradoxides jemtlandicus* is a many jointed species (19 plural segments) which was found in the Elandicus' zone. The second and the last segment are larger than the others, and the rachis of the pygidium has but a single joint.

5. A new species of trilobite from the Dictyonuna shale is described, *Boeckia mobergi.* The pygidial spines are more approximate than in *B. hirsuta.*

6. *Conularia munthei,* is a new species of the monolifera division of Holm, the segmental line of the pyramidal face is triple, the form of the shell and sculpturing of the surface are described. A plate of figures accompanies this article. G. F. M.

Ueber das neue Vorkommen einor untersilurischen Fauna bei Lhotka (Mittelbohmen). J. V. Zelizko.

Herr Zelizko in this communication gives the result of his examination of a lot of fossiliferous rock from the Band *d,* y sent him by professor J. J. John of Brünn for study. It came from a new locality at Lhotka in middle Bohemia and gives some interesting results.

The locality had been visited by Dr. J. Perneo, who had announced it at a meeting of the Bohemian "Landes-museum, and had mentioned the occurrence there of a number of Barrande's species and one new species of Bellerophon, *B. avus,* of the sub-genus Salpinostoma.

In the material sent to professor Zelizko he found quite a number of species which had not been reported by Perneo, some of which had not been previously known from this band.

The following trilobites were found in Dr. Jalm's material: *Placoparia Zippei,* Bœck, sp. *Aeglina princeps* Barr; *Aespeciosa,* Corda, sp. *A. prisca* Barr. *Dalmania atava,* Barr., *D.* sp. *Asphus nobilis,* Barr., *Ogygia,* sp. *Ascidaspis Buchi,* Barr., *Illenus Salteri,* Barr., *I. Panceri,* Barr., *Trinuclus,* sp.

Of Cephalopoda, *Orthoceras,* sp. Of Brachiopoda, *Pater ula bohemica,* Barr., *Discina,* sp. Of Gasteropoda, *Pleurotomaria* sp. Of Conularidæ, *Conularia bohemica,* Barr., *C. proteica,* Barr., *Heyolithes elegans,* Barr., *H. indistinatus,* Barr., *Hyolethus,* sp. Of Lamellibranchiata, *Filius antiquus,* Barr., *Nucula faba Leda bohemica,* Barr. Of Crinoidea, *Entrochus primus,* Barr. *Encrinites* sp Of Cystidians, *Anomalocystites,* sp. Of Hydrozoa, *Desmograptus,* sp., *Ptyograptus ramale Pocta.*

It will be observed that Dr. Zelizko classes Hyolithes with the Cenulariæ, notwithstanding the adverse views of Holm and others. As in his classification of the species found Zelizko arranges Hyolithes between Gasteropod and Lamellibranchs, one may suppose that he leans to the view of Naumayr that they are related to the "snails," i.e. Gasteropods; but the structure of the operculeum is quite different from that of any Gasteropod. Sir William Dawson has called attention to

the resemblance in structure between the shells of Hyolithes and the Brachiopoda.

Holm speaks as follows of this genus and conularia. Between them are great differences. In Hyolithes the shell is solid, rigid, evenly thickened, formed of at least three layers, and composed of calcium carbonate. Conularia is thin, flexible and composed of calcium phosphate and a horny substance. In Hyolithes the shell is bilaterally symmetrical, with dorsal and ventral sides plainly distinguishable. In Conularia the shell is quadrately or rhombically pyramidal, has two symmetrical planes [on each side] and has no distinct dorsal and ventral side. (Swedish Cambrian and Silurian Hyolithidæ and Conularidæ.)

G. F. M.

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CORRESPONDENCE.

"How LONG AGO WAS AMERICA PEOPLED." American Geologist, vol. xxxii, p. 128. Taking this as his text Mr. Marsden Manson calls attention to the need of considering the latitude of a place when determining the number of years since which any given region has been relieved of its load of glacial ice. His remarks relate chiefly to the west coast of North America in which he finds the disappearance of the glacial ice to vary from 50,000 years in the peninsula of Lower California to 1500 in Alaska—a wide difference surely. Without going into his argument, which will be found detailed in the August number of the GEOLOGIST, one may revert to his citation from professor Upham on the probable lapse of time since this continent has been occupied by man. Of the various estimates made by different writers of the time when the Ice age came to a close he says *"Their average of about 8000 years may be confidently accepted as near the truth."*

That this is a modest demand is clear from the result of the study of this period in Europe, and is not without support in this region. Here in eastern Canada we are in the latitude of 45° N, a median position on this coast as regard the great ice sheet of the glacial time, or perhaps nearer its southern border, yet there are indications that a long time has elapsed since the burden of ice was removed from this region.

In the peat bogs that cover extensive tracts along these coasts there is a continuous history extending over many years. They have not been exploited like those of northern Europe, yet they reveal to us some data of general as well as local interest. One small valley on the borders of the city of St. John is occupied by a deposit of this kind which is now mostly in the condition of forest; yet it has passed through the various stages of beaver pond, marsh, peat bog, forest bog, peat bog, forest bog, and is now returning to the condition of a peat

PURSUANT TO THE ACTION OF THE SEVENTH INTERNATIONAL GEOGRAPHIC CONGRESS held in Berlin in 1899, the geographers and geographic societies of the United States are considering plans for the ensuing Congress, which is to convene in September, 1904. It is proposed to have the principal scientific sessions in Washington early in the month, and to have social sessions in New York, Philadelphia, Baltimore, and Chicago, with a final session in conjunction with the World's Congress of Science and Arts in St. Louis. It is provisionally planned also to provide an excursion from St. Louis to Mexico, and thence to points of geographic interest in western United States and Canada.

A Preliminary Announcement is in press and will shortly be issued to officers and members of geographic societies in all countries, and to geographers who may express interest in the Congress and its work. Details have been entrusted to a committee of arrangements made up of representatives from geographic societies in all parts of the United States. The officers of the Committee are: Dr. W. J. McGee (vice-president National Geographic Society), Chairman; Mr. John Joy Edson (president Washington Loan and Trust Company), treasurer; and Dr. J. H. McCormick, secretary. The office of the committee is in Hubbard Memorial Hall, Washington, D. C., U. S. A., where communications may be addressed.

WEST COAST GEOLOGIC NOTES.

DR. JAMES PERRINE SMITH, PROFESSOR OF PALEONTOLOGY IN LELAND STANFORD UNIVERSITY, has been spending the summer in collecting material from the beds in northern Idaho and Shasta and Inyo counties, California, for his monograph on the Triassic Ammonites.

THE UNIVERSITY OF CALIFORNIA HAS HAD TWO PARTIES in the field this summer under the direction of Dr. John C. Merriam, professor of paleontology. One party has been investigating the Quaternary caves of the limestone region along the McCloud river, while another has been collecting Triassic saurians in the beds on Squaw creek, Shasta county. Both parties have been particularly successful and have obtained much new and valuable information.

DR. J. C. BRANNER, ASSISTED BY DRS. NEWSOM AND ARNOLD, has been continuing the work on the Santa Cruz sheet this season. The areal geology on the sheet is nearly finished, but some structural and paleontologic work yet remains to be done.

DR. RALPH ARNOLD, LATE ASSISTANT IN GEOLOGY at Leland Stanford university, has been appointed assistant to Dr. Dall of the United States Geological Survey, and will hereafter make Washington his headquarters.

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NEARLY VERTICAL SANDSTONE DIKE SHOWING VARIATION IN THICKNESS.

THE

AMERICAN GEOLOGIST.

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SANDSTONE DIKES NEAR COLUMBUS, GEORGIA.*

BY S. W. McCALLIE, Atlanta, Georgia.

PLATES XXV-XXVIII.

During the spring of 1901 while making an examination of the banks of the Chattahoochee river south of Columbus for deposits of marls, my attention was attracted by fragments of sandstone strewn along the river banks, just above the water-level of the then swollen stream. These fragments were carefully examined and found to be a rather fine-grained sandstone quite different from any rock occurring elsewhere in the vicinity. At the point where they were first observed no clue was given whatever as to their original source, but further down the stream where the banks became higher and where there were no alluvial deposits to obscure the natural formation, the sandstone was to be seen *in situ,* forming the filling of what appeared to have been at one time open fissures or cracks in the Cretaceous clays. Owing to the high stage of the river at that time, it was found impracticable to make a satisfactory study of the occurrence of the sandstone and only a few general notes were taken. Later, a second, and, finally, a third visit was made to the locality and a more complete examination was made under more favorable river conditions.

The location of these sandstone filled fissures, or what may be termed sandstone dikes, is on the Chattahoochee river, about fifteen miles south of Columbus, at what is known as Slick Bluff. The distance to which these dikes extend along the river is about one mile. They appear to reach their maximum degree of development where the river banks

* Published by permission of the State Geologist.

attain their greatest hight. This, however, is probably due to their better exposure at these points rather than to any other cause.

The dikes vary in size from a fraction of an inch to two feet in width, and cut the enclosing beds of clays at various angles. At some points, they conform with the bedding of the clays and therefore resemble interstratified layers of sandstone, but more frequently they cut the beds of the clays at considerable angles and often stand nearly perpendicular. The beds of Cretaceous clays themselves which are cut by the dikes are often somewhat disturbed and occasionally dip at an angle of from 10° to 15°. Such disturbance as this is of rare occurrence along the Chattahoochee river where the strata are usually nearly horizontal or at most dip only a few feet per mile.

Some of the individual dikes are very variable in width as well as in the direction of their strike. It is not uncommon for the larger dikes to increase to more than twice their usual width within a short distance and also to change their course, thus assuming an irregular or zig-zag direction. The smaller dikes on the other hand are generally more uniform both in their width and their strike. Sometimes the lesser ones continue for a hundred feet or more in a nearly straight line with little or no variation in width. It frequently happens that the dikes, which always have a jointed structure not unlike the rocks of the igneous dikes, divide into nearly equal divisions or they may intersect each other at various angles. More generally, however, both the smaller and the larger dikes are more or less parallel having a trend at an acute angle with the general course of the river.

The sides of the dikes where they come in contact with the enclosing clays usually show very irregular or rough surfaces made up of numerous shallow depressions and their corresponding elevations. Where the elevations and depressions are wanting, the sides of the dikes occasionally exhibit smooth, well polished slicken-sides. These polished surfaces appear to be most abundant in the larger dikes.

The depth to which the sandstone dikes extend is not known. They continue from the top of the river banks which in places are twenty or more feet in hight, to low-water mark below, with but little diminution in size. In the bed of the river

SANDSTONE DIKE CONFORMABLE WITH THE STRATIFIED BEDS OF CLAY.

near where the larger dikes occur, is to be seen during the low stage of water, an outcropping of sandstone which appears to be the exposures of larger dikes than any appearing along the river banks.

The material of the various dikes is quite uniform both in physical structure and in mineralogical composition. It may be described as a light gray, fine-grained sandstone, containing considerable muscovite and some clay, the latter mineral forming a cement which binds the sand particles into a compact mass. In some instances, the sandstone has a yellowish or brownish color, due evidently to the presence of oxide of iron. These colors sometimes alternate with the gray color, thus producing a banded appearance with the bands running parallel with the sides of the dikes.

The individual sand granules are sharp and angular showing but little or no evidence of having been long subjected to the wearing action of the waves or running water. They consist almost entirely of quartz containing little or no coloring matter. The mica which is irregularly distributed throughout the sandstone occurs in small, thin flakes having a silver-like lustre. In no instance does the mica exhibit any evidence of being arranged in layers, but on the contrary it occurs pretty evenly scattered throughout the sandstone dikes quite similar to the occurrence of mica in alluvial sands. The scales of muscovite have flat surfaces and show no indication whatever of having been crushed or subjected to pressure since their original deposition in the dikes.

One of the most interesting features of these dikes, a peculiarity distinguishing them from the sandstone dikes of California described by Dr. J. S. Diller,* is the presence of fossils. These fossils which consist mainly of bi-valves are frequently met with in more or less abundance in all of the larger dikes and in many instances form beautiful casts showing very perfectly both the external and the internal structure of the shell. The arrangement of the shells in the dikes is very irregular and like the scales of mica, shows no evidence of stratification or bedding. The shells occurring in the dikes appear to be identical with the fossils found in the enclosing Cretaceous clays, some of which are made up largely of the casts of bi-valves.

* *Bulletin Geological Society of America*, vol. i, pages 411-442.

uata were found. These occur generally in the Madison beds. That this form reappears here after being absent in the Whitewater, where its place is taken by the *Hebertella occidentalis* (Hall), is an interesting fact in the migration of faunas. A well marked form of Platystrophia was found both in the western localities and very abundantly at the Dutch creek locality. A large number of Bryozoa were collected, which, judging from cursory examination, are all new with the exception of the *Leptotrypa? stidhami* Ulrich.

III. *Note on the genus Strophomena and its type.*

A very lucid history of this genus is given in Hall and Clarke's classic work on the Brachiopoda (Natural History of New York, Paleontology, Vol. VIII, Part I, 1892, pp. 245-252). The essentials of the early history are as follows:

In 1820 Rafinesque (Annales générales des Sciences physiques de Bruxelles, V, p. 232) used the term Strophomènes, without definition, in a list of new genera.

In 1824 Defrance (Tableau des Corps Organisés Fossiles, pp. 5 and 110) cited twice, without definition, the term Strophomène, once for shells from Dudley, England, and again in a list as containing three fossil species, without giving its author or naming any species.

In 1825 de Blainville (Manuel de Malacologie et Conchyliologie, p. 513, pl. liii, 2, 2a) gave a brief diagnosis of the genus,* altered the form to *Strophomena,* cited for an example the *Strophomena rugosa* Rafinesque, stated that the genus contained only fossil species, to the number of three, according to Defrance, and figured the dorsal and ventral aspects of a specimen of the species cited.

In 1827 (Dictionnaire des Sciences Naturelles, tome LI, p. 151) the description, with slight verbal changes, was repeated.

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* "Strophomène. Strophomena. Animal tout-a-fait inconnu. Coquille régulière symétrique, équilatérale, subéquivalve; une valve plate et l'autre un peu excavée; articulation droite, transverse, offrant à droite et à gauche d'une subéchancrure médiane, un bourrelet peu considérable, crénelé ou dentelé transversalement: aucun indice de support."—de Blainville, Man. Malac., p. 513. [Strophomena. Animal altogether unknown. Shell regular, symmetrical, equilateral, subequivalve; one valve flat, the other a little hollowed: hinge transverse, straight, presenting to the right and left of a median notch (delthyrium?), a slight swelling (deltidium?), transversely crenate or dentate: no indication of support (brachial supports?). There is nothing about *Strophomena planumbona* to which such an expression as "transversely crenate or dentate" can apply.

and also a brief description was given of the species *rugosa.** The generic name is spelled *Strophomenes,* as Rafinesque wrote it.

Neither figures nor description seem to the writer to justify Hall and Clarke's remark, "We have here a good description of this American species accompanied by intelligible figures, and although the name has never been current among the naturalists in this country, there seems sufficient reason to believe that it is the same species which was subsequently described as *Leptaena planumbona,* a common fossil in the upper horizon of the Hudson River group in the Ohio valley." The very brief description given will answer for a number of distinct forms, and if the figures were really made from a specimen of the form which Hall described in 1847 under the name of *Leptaena planumbona,* they are very crude indeed, and certainly do not represent so as to be recognized the common *Strophomena planumbona* (Hall) of the Liberty beds of the Richmond.

Some time after the writer had come to this conclusion, he came across in an obscure publication confirmatory evidence in a paper by S. A. Miller on "Strophomena and the type of the genus" (The Natural Science Journal, Vol. I, No. 2, New Bedford, Mass., April, 1897, pp. 29-35). Mr. Miller thinks that Hall and Clarke are entirely mistaken in identifying *planumbona* with de Blainville's *rugosa* (as figured by Hall and Clarke), and thinks the figures suit *Hebertella insculpta* (Hall) much better. But de Blainville's figures suit *H. insculpta* even less than *Strophomena planumbona.* However, it should be said that Mr. Miller judged from Hall and Clarke's reproductions which have made the striation coarser and fail to show the shading of the original figures.

In 1850 King (Monograph of the Permian Fossils of England, p. 103) in speaking of the genus *Strophomena* says that he has little doubt that the *Strophomena rugosa* Raf. is identical with the recently proposed *Strophomena* (*Leptaena*) *planumbona* of Hall; basing his opinion upon "its general form, and its large valve being concave, and the opposite one convex."

* "Strophomène rugueuse: Strophomenes rugosa. Rafin. Coquille bombée en dessous, et dont la valve superiéure est un peu concave et chargée de petites stries rayonnantes. Largeur, un pouce. Fossile de l'Amérique septentrionale."—(D. F.) [=Defrance]. *Dict. Sc. Nat.*, II, p. 151. [Shell convex beneath, and with the upper valve a little concave, and provided with small radiating striae. Size, an inch. Fossil from North America.]

It is to be noted as pointed out by Meek (Geol. Sur. Ohio, Pal., Vol. I, 1873, p. 81), that Hall's figures (Nat. Hist. New York, Pal., Vol. I, pl. 31B, figs. 4a, 4b) of *Leptaena planumbona* are inaccurate in representing strong concentric transverse folds or wrinkles. It is a little singular that de Blainville's figures if they really represent the same shell, should have the same defect. The *Strophomena planumbona* in its typical, common form has a smooth surface with the growth lines rarely conspicuous.

In 1852 Davidson (Monograph of the British Fossil Brachiopoda, Part I, p. 105) carefully defined the "Genus *Strophomena* (Rafinesque) Blainville, 1825," gave as the "Type—*S. rugosa* Raf.?=*S. planumbona* or *S. alternata*," with the remark that "no one seems to have clearly pointed out or identified with certainty *S. rugosa* of Raf."

In a tract published at Philadelphia in Oct., 1831, Rafinesque defined his genus thus: "Strophomenes, Raf. Equilateral, hinge broad, great valve notched by a lunulate sinus receiving a lunulate projection from the smaller valve." No species is mentioned. In November of the same year he defined two species *Str. laevigata* and *Str. flexilis.* Neither can be recognized from his short descriptions.

Beginning with Conrad and Emmons, 1839-1842, the name *Strophomena* has been widely used in American paleontological literature in a broad sense, a common Ordovician form, (now the *Rafinesquina alternata* of Hall and Clarke, 1892), with its innumerable varieties, gradually coming to typify the genus.

There is nothing about the *Strophomena planumbona* (Hall) to suggest the descriptive term *rugosa.* It does seem probable, indeed almost certain, that Rafinesque applied the term to the shell now commonly known as *Leptaena rhomboidalis,* (see Hall, Nat. Hist. New York, Pal., III, p. 195; Meek, Geol. Sur. Ohio, Pal., I, p. 73; S. A. Miller, The Natural Science Jour., I, pp. 30, 33). By the time it came into de Blainville's hands, in some way a transfer of name had taken place (due to mixing of labels?).

However it does not matter what form Rafinesque may have intended by *Strophomenes rugosa,* since he never described it. The genus must rest upon de Blainville's definition and figures, inadequate or erroneous though they be. These probably suit

the genus *Strophomena* as now understood,—at least King and Davidson so understood them, and they really established the genus,—though they do not suit *Strophomena planumbona* as its deltidium is much narrower than that represented in de Blainville's figures, a character which would not likely be misrepresented in a drawing, nor does the general outline of *S. planumbona* agree with the figures. At the same time it must be remembered that de Blainville expressly credits the genus to Rafinesque. But de Blainville's *rugosa* (which was almost certainly not Rafinesque's *rugosa*) is not recognizable from figures or description. S. A. Miller, in the paper already cited, takes the ground that as *alternata* has typified, by a sort of unwritten consensus of opinion, *Strophomena in* American paleontological usage for fifty years, it should be regarded as the type, and so Hall and Clarke's genus *Rafinesquina,* based on this species, is superfluous. With this conclusion the writer cannot agree.

The purpose of the fundamental law of priority in the biological sciences is to secure fixity and stability, to prevent the confusion engendered by having a diversity of names for the same object, or one name for different objects. We shall never know what Rafinesque's *rugosa* was. We do not know what de Blainville's *rugosa* is. It is not impossible that the specimen figured by de Blainville, the type, may still be found in some one of the collections in Paris, if the original label has been preserved with it. The figures given, in the writer's opinion, are too inaccurate to permit the recognition of the specimen from them, unless they represent a species which no one has yet suspected of identifying as *S. rugosa.*

Under the circumstances and with present light, it seems to the writer that the wisest solution of the difficulties and the one that observes the real intent, if not the exact letter of the law of priority, is to recognize, with Rafinesque for its author, the genus *Strophomena* as understood by King, Davidson, Hall and Clarke, Winchell and Schuchert, with the *Strophomena planumbona* (Hall) as its type, and drop the name *rugosa* altogether. It is with this interpretation that the name *Strophomena planumbona* (Hall) has been used in this paper.

IV. *Table showing the stratigraphic sequence of the subdivisions of the Cincinnatian series in the Cincinnati area.*

Silurian			Niagara.
			Clinton.
Ordovician	Cincinnatian series	Richmond	Madison.
			Whitewater.
			Liberty.
			Waynesville.
		Lorraine	Warren.
			Mount Auburn.
			Corryville.
			Bellevue.
			Fairmount.
			Mount Hope.
		Utica	Upper.
			Middle.
			Lower.
	Trenton.		

SOME RECENT ASPECTS OF THE PERMIAN QUESTION IN AMERICA.

BY CHARLES R. KEYES, Socorro, New Mexico.

After seeing at close range the "Red Beds" of New Mexico, I am convinced that the Permian question in America is not to be settled on the basis of Kansas stratigraphy. Just as the Cretaceous of the Upper Missouri river region is not to be considered in terms of the Texas Cretaceous, so in Kansas the history of late Paleozoic times is far more complex and intricate than has been commonly supposed.

Until within the past two years, accident of location threw me into closer association with the Kansas rocks than with any other of the American upper Paleozoic sections. My references to strata, which have been called Permian, have been chiefly taxonomic and nomenclatural in character. My comparison of the Kansas beds, often called Permian, and the beds of the original Permian in Russia appeared to me conclusive on the point that the nomenclature and classification of the upper Paleozoic rocks of the United States are not advanced by retaining longer Murchison's title of Permian.

In America, the Permian problem promises to be a much discussed question. The Kansas beds often assigned this age have thus far come in for most consideration; but the question is a far broader one. It is not at all likely that Kansas will ever af-

ford solutions to the chief problems which now demand attention before all others. Everything points to districts outside of this state for the critical information so long sought.

The recent excellent paper on the "Revised Classification of the Upper Paleozoic Formations of Kansas,"* by professor Charles S. Prosser, sums up certain phases of our knowledge on some of the vexed questions presented. Not the least valuable feature of professor Prosser's notes on Kansas geology is the clearness with which he usually states the positions and observations of others and adjusts them to his own plan. Before passing to the main theme, however, I wish to call attention briefly to several of the points especially dwelt upon in the recent paper just referred to; and to restate several of my conclusions formerly reached, which I think professor Prosser has not reiterated quite in the sense I originally intended—a fact due partly no doubt to my own neglect to make certain statements sufficiently clear.

Whether or not the term Oklahoman shall eventually be regarded as the proper serial title for one of the provincial terranes of the Carboniferous in the continental interior makes little difference; but I cannot agree with professor Prosser that it is synonymous with Cragin's name Big Blue series of Kansas. When the title Oklahoman was first proposed for the uppermost series of the Carboniferous its upper limits were not very definitely fixed—further than it was stated that in a general way the terrane corresponded to what had previously been called Permian. At that time the Red Beds were regarded as post-Carboniferous in age. Until more conclusive and extensive evidence is forthcoming there seems at the present time no good reason for considering the geologic age of all of these formations Paleozoic.

Notwithstanding the very positive statements of professor Prosser that the Oklahoman is coextensive with Cragin's Big Blue Series it is very clearly not exactly so. As it now appears, even according to professor Prosser's published data, the Oklahoman in central Kansas includes at the base at least one important formation more than the Big Blue series; and at the top at least one formation less. The Oklahoman series in Kansas is delimited above by the top of the Marion limestones.

** Journal Geology*, vol. x, pp. 703-737, 1902.

In my various papers, with one exception due to a typographical error arising from inability to see the proof sheets of the article, this fact is clearly indicated. This is particularly emphasized in the memoir frequently quoted by professor Prosser, on the detailed comparison of the Upper Carboniferous of Kansas with the Russian Permian.

In reality, the Oklahoman is very different in its delimitations from the Big Blue series, notwithstanding the fact that in central Kansas the two may appear perhaps at first glance to be approximately the same. Were only Kansas to be considered there would probably be little hesitation in reaching a satisfactory conclusion. In this case so far as I am personally concerned there would be no necessity of quibbling over what might be regarded as mere titles, and professor Cragin's name might be easily accepted if it properly expressed the stratigraphy.

It so happens that the horizon of the summit of the Marion limestones is stratigraphically a very important one. Its significance is not so apparent in Kansas as farther southward. The most remarkable developments of the vaguely understood "Red Beds" are found in Oklahoma, northwestern Texas and to the westward in New Mexico. It is here that the real differentiation of the Upper Carboniferous is to be considered in its various phases. The history of the Oklahoman series is a very different one from that indicated within the stratigraphic limits of the so-called Big Blue. The two terms are not synonymous by any means. They stand for two very different ideas. A full statement of these distinctions will probably be shortly given out.

Tentatively the Cimarron terrane is regarded as the uppermost series of the Carboniferous of the continental interior. However, it is by no means certain as yet that either the name can be retained or the series kept intact. Should the title be preserved it is quite likely that the limits of the formation to which it is applied will have to be considerably modified. As in the case of the Oklahoman the criteria of ultimate classification are to be drawn not from Kansas but from the country to the southwest.

There should not be any juggling of words in such questions as those under consideration. Yet professor Prosser says: "A

geologist familiar with the Kansas formations wrote as follows concerning the provincial series question: 'Grant, as Keyes maintains, that Permian is the name of a provincial series, then where a similar series is found with similar fossils the name ought to be given. All our names were names of provincial series at first. What was Devonian but the name of a series of rocks in Devonshire, England? When found in New York, by this argument, they should be called New Yorkian or some other American name.' "

Now it is extremely unfortunate that after the geologists the world over, and the majority of paleontologists also have come to a general understanding to use certain words denoting taxonomic rank in a strictly technical sense that some paleontologists should still insist on using such words in a number of very different senses. There are fundamental ideas that no mere play of words can alter. The fact that Kansas geologists designate single calcareous layers by the exalting title of *system,* as the Iola Limestone System, for instance, does not delude geologists generally into thinking for a moment that the signification is the same as for the whole Carboniferous sequence.

The statement that "all our names were names of provincial series at first" is certainly not correct. The original Devonian of England may have lately proved to be merely a provincial series in the modern technical significance of the word. But before this fact was discovered the term had been found to cover sequences equivalent to systems, in other parts of the world. If in England the Devonian period is represented only by a single stratigraphic series the latter certainly would not be called the Devonian series, but a series as yet unnamed. If within the New York province the Devonian period has but one series, it surely would not be denominated the Devonian series. The Yorkian series would at least be appropriate and certainly proper as a title for these rocks.

We have a very much better illustration in certain contiguous geographic provinces in the United States. The Mississippian series of the continental interior represents early Carboniferous sedimentation. In the northern Appalachian province there is also early Carboniferous deposits; but the series represented cannot be advantageously called Mississippian. Nor is it Mississippian. Green Briar-Poconoan series may be

the proper title; but never Mississippian. Likewise in the Rocky Mountain or Basin provinces no part of the early Carboniferous rocks can be jammed into a Mississippian series. Series there are here, but never Mississippian series. If by any twisting of titles we are permitted to extend the stratigraphic, serial title of Mississippian so as to cover all the early Carboniferous deposits of the continent or of the world, then we shall have to find new names for each of the several provincial series.

"Then when a similar series is found with similar fossils the same name ought to be given." Certainly! if our classification is to be constructed on a purely artificial and homotaxial basis. Not if we are to preserve the chronologic idea.

Regarding the original Permian professor Prosser states: "Apparently the main point of Dr. Keyes' contention is 'That Permian, as originally proposed, applies to a provincial series, and, according to our usual standard, has, at best, a taxonomic rank below that of system.' Yet he states it is probable that its main subdivisions will be elevated 'to the rank of series,' which, instead of causing the name Permian to be dropped, as he suggests, will more probably leave it with the rank of a system as originally defined by Murchison."

This conclusion by no means follows from the premises quoted. Raising the taxonomic rank of the present main subdivisions of the Russian Permian to that of series does not necessarily make the Permian a good system. Neither does such procedure make it obligatory to retain the name Permian in any capacity, either in this country or in Russia.

The fact that the Paleozoic beds of Kansas above the Missourian series are 3,000 feet thick is no argument whatever that they belong to a distinct system. Neither does it argue in the slightest degree for the retention of the name Permian for any American rocks. The shadow should not be mistaken for the substance. I do not at this time contend that the Paleozoic beds above the summit of the Missourian series are not of sufficient importance to be regarded as equivalent to a system. Heretofore I merely have been unable to see any good grounds for retaining the title Permian for any Kansas formations. Recent work on the Red Beds beyond the Kansas boundaries very much strengthens this position.

A singular argument does professor Prosser use to retain the title of Permian as the name of a system and period. He refers to half a dozen Russian writers who have used the title in this sense. No allusion whatever is made to a much larger number of Russian geologists who are equally distinguished and who all have worked extensively in the typical regions, but who hold very different views. This method of presentation is hardly the scientific method.

New Mexico School of Mines, May 1, 1903.

THE GLACIAL LAKES HUDSON-CHAMPLAIN AND ST. LAWRENCE.

By WARREN UPHAM, St. Paul, Minn.

Two years ago, in July, 1901, I found the opportunity, long desired, for an examination of lake Champlain and lake George, of the country south to Fort Edward, including the very low parts of the watershed between these lakes and the Hudson river, and of the beautiful and partly grand Hudson valley, thence to its mouth. Along this course extended the long and comparatively narrow lake Hudson-Champlain, held on the north by the barrier of the receding continental ice-sheet.*

When the growing glacial lake in the Champlain basin became confluent, around the north side of the Adirondacks, with its contemporary, lake Iroquois in the basin of lake Ontario, the resultant very large glacial lake, of irregular outlines, still occupying the Hudson-Champlain valley and the Ontario basin, spread far north and northeast in the great St. Lawrence valley. This vast lake, the latest in the complex series formed on the northern border of the United States and in southern Canada by the departing ice barrier, grew as the front of the ice melted back, until it reached northwesterly along the course of the Ottawa to some distance above Allumette island, and northeasterly to the vicinity of Quebec. Its existence was

* C. H. HITCHCOCK, *Geology of Vermont*, 1861, vol. i, pp. 93-167, with map. J. S. NEWBERRY, *Pop. Sci. Monthly*, vol. xiii, 1879, pp. 641-660. F. J. H. MERRILL, *Am. Jour. Sci.*, third series, vol. xli, pp. 460-466, June, 1891. W. M. DAVIS, *Proc., Bos Soc. Nat. Hist.*, vol. xxv, 1891, pp. 318-334. BARON GERARD DE GEER, *Proc*, *Bos. Soc. Nat. Hist.*, vol. xxv, 1892, pp. 454-477, with map; also (excepting the map) in AMER. GEOLOGIST, vol. xi, pp. 22-44, Jan., 1893. S. PRENTISS BALDWIN, AMER. GEOLOGIST, vol. xiii, pp. 170-184, with map, March, 1894. WARREN UPHAM, *Bulletins Geol. Soc. Am.*, vol i, p. 566; vol. ii, p. 265; vol. iii, pp. 484-487 (first using this name, Hudson-Champlain, 1892).

terminated by the continued melting of the ice-sheet, at last allowing the sea to come in past the site of Quebec and to cover, at a somewhat lower level, nearly the same area as the previous glacial lake, which eight years ago I named lake St. Lawrence.*

The exact boundaries of both these glacial lakes at their earliest and highest stages, are undoubtedly traceable by more or less distinct shore erosion, beach deposition of sand and gravel, and deltas of inflowing streams. But these evidences of the old shore lines are mostly very dim, for these lake areas appear not to have been occupied by their bodies of water longer than the lake Agassiz basin, and their usually more irregular contour of the inclosing slopes gave less chance for coastwise drift and formation of beach ridges. Only at a few places have their shores been identified, by Davis, Baldwin, and Baron de Geer, with determinations of their altitudes.

According to my observations, the general absence of any considerable lacustrine deposits, excepting rare and small deltas, which must be searched for by leveling, proves the geologic brevity of the duration of these lakes. Their existence could have measured only a very small fraction of the period of the great Quaternary lakes Bonneville and La Hontan, with their conspicuous shore terraces and thick lacustrine sediments. Instead, the lakes Hudson-Champlain and St. Lawrence evidently belong in the same class, in respect to their duration, with the other great glacial lakes of the Laurentian drainage area, as lakes Iroquois, Algonquin, and Warren, and with lake Agassiz, for which last I have estimated a duration equal to no

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* "Late Glacial or Champlain Subsidence and Re-elevation of the St Lawrence River Basin," *Geol. and Nat. Hist. Survey of Minnesota*, 23d Annual Report for 1894 (published 1895), pp. 156-193, with map; also partly in *Bulletin Geol. Soc Amer.*, vol. vi, pp. 21-27, Nov., 1894, and *Am. Jour. Sci.*, third series, vol. xlix, pp. 1-18, with map, Jan., 1895.

SIR J. WILLIAM DAWSON, The Canadian Ice Age (Montr al, 1893). pp. 301, with maps and sections, views of scenery, and nine plates of Pleistocene fossils. This volume sums up the author's work from 1855 on the glacial drift and associated lacustrine and Champlain marine formations of the St. Lawrence valley, embodying the studies which had been published in many papers in the "*Canadian Naturalist and Geologist*" and elsewhere. He had given a similar summary in a pamphlet of 112 pages, "Notes on the Post-pliocene of Canada," in 1872.

G. K. GILBERT, "Changes of Level of the Great Laks," in *The Forum*. vol. v, pp. 417-428, June, 1888; "History of the Niagara River," Sixth Annual Report, Commissioners of the State Reservation at Niagara, for 1889, pp. 61-84, with eight plates (also in the Smithsonian An. Rep. for 1890, pp. 231-257).

J. W. SPENCER, "A Review of the History of the Great Lakes." AMER. GEOLOGIST, vol. xiv, pp. 289-301, Nov., 1894 (containing citations of many earlier papers by PROF. SPENCER and others.

BARON DE GEER, S. PRENTISS BALDWIN, and WARREN UPHAM, as before cited for Lake Hudson-Champlain.

more than a tenth part of the Postglacial period, or, in round numbers, probably about 1,000 years.*

If we thence attempt to estimate the stages of these several glacial lakes, starting from professor N. H. Winchell's computation of about 8,000 years as the lapse of time since the beginning of erosion of the gorge between Fort Snelling and the Falls of St. Anthony in Minneapolis, we may suppose the existence of lake Agassiz, in all its thirty successive levels of decrease in both depth and area, to have ended about 7,000 years ago. Lake Warren may be assigned to approximately the same duration of about 1,000 years after the St. Anthony gorge began to be eroded. With the end of lake Warren, the cutting of the Niagara gorge between Lewiston and the present position of Niagara falls began, and has occupied a less time, therefore, than the gorge below Minneapolis. Lake Iroquois, beginning at the same date as the Niagara gorge, lasted perhaps 1,000 years, ending some 6,000 years ago, which likewise marked the time of transition of lake Hudson-Champlain into the incipient lake St. Lawrence. In its turn, this latest great ice-barred body of water endured probably another 1,000 years, to about 5,000 years ago. It ended by the melting of a gap in the ice-sheet barrier, admitting the sea to the former lake area. Finally, the last remnants of the ice-sheet on the Adirondacks, the White mountains and northern Maine, and in the central parts of British America, both west and east of Hudson bay, may have lingered 1,000 to 2,000 years more, until only 4,000 to 3,000 years ago. Although these crude and offhand estimates have no exact value, they seem to give a safe conclusion that the closing Champlain epoch of the Ice age was geologically short and near our own times, since it extended, indeed, into the period of Egyptian or even Greek history.

Five marginal moraines in central and northern Minnesota were formed contemporaneously with lake Agassiz; and doubtless also an equal or larger number of these belts of knolly and hilly drift, marking stages in the wavering recession of the ice-sheet while it was the barrier of that lake, will be found in Manitoba and farther north. Earliest of these moraines in Minnesota are two that are merged in the prominent Leaf hills,

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* **The Glacial Lake Agassiz,** *Mon. xxv, U. S. Geol. Survey,* **1895, pp. 238-244.**

the most massive morainic deposits in the Northwest, situated nearly five hundred miles north of the drift boundary. These great moraines seem very probably correlative, in their date of accumulation, with the outermost moraines of New Jersey and Long Island, on or very near to the extreme drift margin, as was once suggested to me by Leverett, which would place the beginnings of lakes Agassiz and Warren slightly earlier than that of lake Hudson-Champlain. But this glacial lake, existing first near the site of New York city, had grown northward along the Hudson valley, following the glacial retreat, until it reached probably to the vicinity of Albany, before lake Warren was succeeded by lake Iroquois. The ensuing duration of the latter lake coincided with the farther growth of lake Hudson-Champlain along all the Champlain basin; and lake St. Lawrence, in its expansion to Quebec, continued with the same outflow by the mouth of the Hudson. All the moraines of New York and New England, as partly traced by Chamberlin, Fairchild, Hitchcock, Shaler, Woodworth, and the present writer, excepting the outermost on Long Island, Martha's Vineyard, and Nantucket, besides other moraines to be traced in Canada, were contemporaneous with these lakes. Any single moraine, or drumlin, kame, or short esker, could therefore have required no more than a few years or decades for its formation, with the recession of the ice-sheet past its situation, while even the most prolonged esker series of Maine would be formed in a few centuries.

Absence of marine fossils in the beds of modified drift overlying the glacial drift on the shores of southern New England, Long Island, and New Jersey, and water courses which extend from the terminal moraine on Long Island southward across the adjacent modified drift plain and continue beneath the sea level of the Great South bay and other bays between the shore and its bordering long beaches, prove that this coast stood somewhat higher than now when the ice-sheet there extended to its farthest limit. Its greater elevation was maintained while the ice receded, and sufficed to hold the water of the Hudson valley at a little hight above the sea, as probably twenty-five or fifty feet. It seems certain that this was a lake, as its deposits along all the Hudson valley have no marine fossils. The upper limit of these deposits rises gradually northward,

passing far above the limit of the fossiliferous marine deposits in the southern part of the basin of lake Champlain.

Northward from the vicinity of the city of New York the land was then depressed and has since been elevated, as shown by the hights of the uppermost shore and deltas of this lake Hudson-Champlain, which, as determined by Davis, are 180 feet above the sea at West Point, fifty-two miles north from the mouth of the Hudson at the Narrows; 275 feet at Catskill, about 110 miles from the Narrows; and 325 to 340 feet in and near Albany and Schenectady, at 145 to 160 miles. The present ascent of the originally level shore is thus 160 feet in about 100 miles.

Nearly the same gradient of differential elevation, but somewhat increased, continues north to Chesterfield, N. Y., on the west side of lake Champlain opposite to Burlington, where Baldwin reports a series of eight beaches referable to the successive water levels of lake Hudson-Champlain, lake St. Lawrence, and the sea in the Champlain basin, their hights above the sea level of today being 550 feet, 530, 470, 423, 386, 365, 335, and 290 feet. This locality is 270 miles north from the Narrows; and the lowest shore in the series is nearly 200 feet above lake Champlain, which has a mean level of 97 feet above the sea, with a maximum depth of 402 feet. The lower four of these beaches belonged to the Champlain arm of the enlarged Gulf of St. Lawrence, as shown by the hight of its sand deltas and associated fossiliferous clays; but the four higher beaches represent stages of the two earlier glacial lakes.

A large delta plain, which I examined, composed of horizontally bedded sand and gravel, was formed at the earliest and highest level of the lake Hudson-Champlain around the town of Saratoga Springs and for a few miles southward, having a hight of about 375 to 390 feet above the sea. Next to the northeast, for about five miles, at the same or a slightly greater altitude, are abundant short esker ridges of coarser gravel, ten to thirty feet high above the intervening hollows. Here the waning ice-sheet supplied abundant englacial and finally superglacial drift to the streams of its melting and of attendant rains, where confluent glacial currents and slopes of the ice surface met from the northeast and northwest.

Ten miles farther north, at Glens Falls, I found another delta plain of the same character and origin, extending two miles northward from the Hudson river, at the estimated hight of 400 to 410 feet above the sea. Thence northward, on the railroad route to lake George, a most notable series of eskers, 20 to 50 feet high above their hollows, reaches five or six miles, inclosing Glen lake, 402 feet above the sea, and forming the divide crossed by this railroad, at the altitude of 575 feet. The gravel of the eskers has in many places plentiful stones, well rounded by water-wearing, as large as one and a half to two feet in diameter. All these extensive modified drift deposits, like those of Saratoga Springs, were doubtless brought by confluent drainage to a re-entrant angle of the retreating ice border.

Next to the north, around Caldwell, at the south end of lake George, and along the entire extent of this beautiful lake, 323 feet above the sea, 30 miles long, and from a half mile to two miles wide, gemmed with many small islands and inclosed on each side by great mountains, the drift consists almost wholly of till, and I saw no important delta accumulations, either at the old level of the lake Hudson-Champlain or on the present lake shore. The lowest pass on the divide of lake George and the Hudson is between French and Sugar Loaf mountains, as shown by the Glens Falls map sheet of the U. S. Geological Survey, and has an altitude of 349 feet above the sea, or only 26 feet above the lake. Through this pass the water of the lake Hudson-Champlain extended with a depth of about 75 feet, and its depth above lake George was about 100 to 150 feet, increasing from south to north.

Till also constitutes the principal part of the drift northward along the mountainous west side of lake Champlain, with no conspicuous delta accumulations of modified drift nor later stream deposits, for the distance of nearly fifty miles to the Au Sable river. Neither there nor on lake George can any shores of the old glacial lakes, or of the sea later and lower, be traced without systematic search with leveling.

Delta plains were also accumulated in the glacial lake of the Hudson valley after the land had been somewhat uplifted, these being mainly supplied by stream erosion of earlier large deltas, which then, on account of the progressing elevation, stood 100,

feet or more above the lake. In the west part of Albany such a lower delta forms a plain 200 to 225 feet above the sea, extending westward from Washington park. Another is well developed at the west side of lake Saratoga, which is 204 feet above the sea, the plain being at 270 to 280 feet, a few miles east from the delta of Saratoga Springs. A third is at Sandy Hill, on the Hudson, about two miles southeast of Glens Falls, having a hight of 290 to 300 feet above the sea, with an extent of two miles from south to north and a width of one mile.

Adjoining the last, and continuing to the south, east, and northeast, is a still lower delta, reaching from Fort Edward about eight miles northeast, with its margin mostly about a third of a mile west of the railroad and the Champlain canal. Its hight, which decreases northward, is about 100 to 75 feet above the canal, or 250 to 225 feet above the sea. The several levels of the deltas, from the highest, at Glens Falls, to these last noted, mark stages of the gradual elevation of the land and consequent lowering of the shore lines along the sides of the valley.

The delta at Fort Edward and northeastward probably is referable to the glacial lake St. Lawrence, which would then have covered the low divide between the Hudson and lake Champlain on the route of this canal, 147 feet above the sea, and 50 feet above the lake. There is no evidence that any stream has flowed across the divide, which is a wide and nearly flat tract of the glacial and modified drift, only four miles distant from the Hudson at Fort Edward. Wood creek flows thence north-northeasterly about twenty miles to the river-like southern end of lake Champlain at Whitehall. About ten miles from Fort Edward, the creek passes from the open valley of the Hudson into a very narrow defile inclosed by rock cliffs, with bold hills rising near at each side, and ascending northwesterly to the front range of the Adirondacks; but the lower valley, approaching Whitehall, expands to a width of nearly a mile.

After the ice-sheet blockade on the lower part of the St. Lawrence basin was melted through, the sea came in, as is known by its fossiliferous deposits, reaching to the south part of the basin of lake Champlain, to the Thousand Islands at the mouth of lake Ontario, and at least to Pembroke and Allumette

island, in the Ottawa river, about seventy-five miles above the city of Ottawa. The uplift of this region from the Champlain sea level was about 375 feet in the St. Lawrence valley opposite the Saguenay, and about 560 feet at Montreal; 150 to 400 or 500 feet, increasing from south to north, along the Champlain basin; about 275 feet at Ogdensburg; and 450 feet near Ottawa. The differential elevation was practically completed, as is known from the boreal character of the Champlain marine molluscan fauna, shortly after the departure of the ice-sheet.

This elevation of the land about the north part of lake Champlain, to a greater amount than about its southern part, caused the lake, remaining after the sea was drained away, to rise southward into a narrow preglacial valley, extending thirty miles north from Whitehall, closely bounded by steep and partly precipitous hills and mountains.

ON NEW SILURIC CYSTOIDEA, AND A NEW CAMAROCRINUS.

By CHARLES SCHUCHERT, U. S. National Museum.

The following descriptions of new cystids are taken from an extended paper treating of these forms from the Manlius and Coeymans formations. As the publication of this paper will be delayed six months or more on account of the prepartion of the necessary illustrations, these descriptions are offered at this time to enable the writer and others to distribute their duplicate material.

Jaekelocystis n. gen.

Definition.—Apiocystinæ with the theca pyriform or globular in outline, rounded oval or four sided in transverse section and composed of eighteen plates. These are arranged as follows:

Basal row has plates 4, 1, 2, 3.

Second row has plates 5, 6, 7, 8, 9.

Third row has plates 10, 11, 12, 14.

Fourth row has plates 16, 17, 18, 13, (19 absent), 15.

Fifth row has deltoid 21. It is a very small plate situated at the top of plate 18 and between it and 13, and has a comparatively large hydropore, but a madreporite does not seem to be

present. Plate 19 of other genera not developed. Anal area small but conspicuous and protruding, consisting only of the pyramid of six pieces. The prominence of the anal area is due to the protrusion of the bounding thecal plates of which there are four, or plates 7, 8, 13 and 14. One basal and two upper very small, discreet pectinirhombs. The parts on plates 1, 12 and 14 as a rule do not show the dichopores as these are deeply situated each in a pit with a high margin. Dichopores few.

Ambulacra normally four in number. These are R I, R V, R IV, and R II. In rare cases either R I or R II may be absent, or R V may be forked. Ambulacra depressed, more or less deeply excavated and, in normal individuals, continuing to or near to the column. Brachioles moderately abundant, short and stout.

Column comparatively stout. Length unknown.

Genotype, *J. hartleyi*, n. sp.

The genus is named for Doctor Otto Jaekel of the Geological Institute of the Friedrich-Wilhelms University, Berlin, Germany, in recognition of the great service he has rendered paleontology by the very detailed description of the "Thecoidea und Cystoidea" forming volume I of his great contemplated work on the "Stammesgeschichte der Pelmatozoen."

Jaekelocystis hartleyi n. sp.

Length of a full grown theca 15 mm., width and depth about 11 mm.

Ambulacra narrow, excavated into and but slightly elevated above the theca, and extending, in normal specimens, to the column. Each pair of ambulacra, or R I and R II, or R IV and R V, converging and almost touching each other near the column. In one individual R I is but half the normal length and R II is almost aborted, having but six brachioles. In another individual R I is entirely undeveloped while in a third specimen the absent one is R II. In a fourth specimen R V is forked, the branch developing on the left. In full grown specimens there are about thirty-four brachioles to each ambulacrum, seventeen on either side. Brachioles stout and folded over each other medially; length unknown but apparently quite short. Ambulacral grooves narrow and shallow with very minute ambulacralia.

Dichopores on plates 1, 12 and 14 not shown at the surface as they are deeply situated within small oval pits each with a rim highly elevated above the surface of these plates. Those on plates 5, 18 and 15 show the dichopores with the excavation deepest orally and are here delimited by a crescentic lip. About eight folds in each half-rhomb.

Hydropore conspicuous, situated on a small piece (plate 21), placed above and between plates 18 and 13. No madreporite discernable here.

Anal pyramid small, not strongly elevated, composed of six pieces, but made quite prominent by the protrusion of the bounding margins of the thecal plates 7, 8, 13 and 14.

Column comparatively stout and, as is usual in cystids, composed of thick segments near the theca. Length unknown.

Formation and locality.—A very common species in the quarries and elsewhere near Keyser, West Virginia. Several hundred specimens have been seen. The first specimen was dug up near Judge Alkire's house by Mr. Frank Hartley of Cumberland, Maryland. It is associated with *Sphaerocystites multifasciatus, S. globularis,* and *Pseudocrinites gordoni,* together with the above, these being the four common species of the cystid beds of the lower Manlius formation about Keyser. It gives the writer pleasure to name this species for its discoverer in recognition of his enthusiasm and untiring efforts in the unearthing of many new Siluric and Devonic species of Western Maryland.

Cat. number 35,055 U. S. N. M.

Sphaerocystites Hall.

Sphaerocystites Hall, Amer. Jour. Sci., sec. ser., XXV, 1858, p. 279.—Hall, Nat. Hist. N. Y., Pal. III, 1859, p. 130.

Sphaerocystis Haeckel, Die Amphorideen und Cystoideen. Beit. Morph. u. Phyl. d. Echinodermen, Leipzig, 1896, p. 133. —Bather, Treatise on Zoology, Pt. III, Echinoderma, London, 1900, p. 63.

Jaekel's* definition of *Sphaerocystites* cannot be accepted as it is based not on the genotype *S. multifasciatus,* but on *S. dolomiticus* Jaekel of the Niagaran dolomites of Chicago, Illinois, the latter having a greater number and a different arrange-

* Stammesgeschite, etc, i, 1889, pp. 288-9.

ment of the thecal plates. It is here made the type of a new genus, *Coelocystis*.

Emended definition.—Callocystinae with the theca varying between depressed echinus-shape with a deeply excavated base to elongate-globular form and with almost no excavated base. Theca with eighteen plates arranged as follows:

Basal row has plates 4, 1, 2, 3.

Second row has plates 5, 6 (sometimes part of 12), 7, 8, 9.

Third row has plates 10, 11, 12 (7, 8), 14.

Fourth row has plates 16 (17 absent), 18, 13, (19 absent), 15.

Fifth row has deltoid 21 with madreporite and hydropore.

Anal area not prominent, bounded by thecal plates 7, 8 and 13. It is composed of two circles of plates, an outer of from 10 to 14 pieces of very variable sizes, and the pyramid with 6 or 8 pieces.

One basal and two upper discreet pectinirhombs with numerous dichopores.

Ambulacra not much elevated above and but slightly excavated into the theca, beginning with four rays and bifurcating variously in different specimens of the same species until 27 branchlets result. Brachioles widely separated, slender, short and club-shaped.

Madreporite large, with a small hydropore immediately beneath. The latter is closed by a pyramid of 4 or 5 pieces.

Column stout, tapering rapidly for a short distance and then hardly at all throughout its length. Total length about 95 mm. Base of attachment terminating in a few roots.

Genotype, *S. multifasciatus* Hall.

Sphaerocystites globularis n. sp.

Length of a large and regular theca 22 mm., transverse diameter 20 to 21 mm. Base not excavated. Plate 12 resting on plate 6 of the second circle.

Ambulacra branching with no apparent regularity, the branches in adults varying between 9 and 14. Ambulacralia about 7 to one parambulacralium.

Anal pyramid depressed, composed of 8 pieces and surrounded by a ring of 4 large and 10 small plates.

Hydropore minute closed by a pyramid of 5 pieces and situated immediately in front of the elongate dumbell shaped madreporite on plate 21.

Column tapering rapidly for a very short distance and then hardly at all throughout its length. Total length about 95 mm., with the root end about 7 mm. high. First 11 segments beneath the theca thinnest with angulated peripheries followed by about 65 segments of nearly equal size and rounded edges.

This species is readily distinguished from the associated *S. multifasciatus* by the globular form of the theca, the non-excavate base, smaller number of ambulacral branches causing the surface of the theca to appear smoother; and finally by the higher position of plate 12 which does not attain the basal row as in that species.

Formation and locality.—Not rare in the cystid beds of the Manlius in the quarries near Keyser, West Virginia. A specimen with the entire column was found by Mr. Gordon in the Bryozoa beds at Devil's Backbone, near Cumberland, Maryland.

Cat. number 35,953, 35,077, U. S. N. M.

Coelocystis n. gen.

Hemicosmites Hall (non von Buch), Twentieth Rep. N. Y. State Cab. Nat. Hist., rev. ed. 1868 [1870], p. 359.

Sphaerocystites Jaekel (partim, non Hall), Stammesgeschichte der Pelmatozoen, I, Berlin, 1899, p. 289, fig. 63; also p. 307.

Until recently *Sphaerocystites* seems to have been based upon a single example, the holotype of *S. multifasciatus*. As the specimen did not permit Hall to decipher the thecal structure, Jaekel gave the plate formula for *Sphaerocystites*, but based it upon *S. dolomiticus* Jaekel=*Hemicosmites subglobosus* Hall. The present work gives the plate formula for *Sphaerocystites* based upon the original genotype *S. multifasciatus* and the study has shown that Jaekel's type is of quite another and more primitive genus. For this reason the Niagaran form is distinguished under the generic name *Coelocystis*, having reference to the deeply invaginated base of the theca.

Hemicosmites is quite a different genus as the plate formula is 4 + 6 + 9 + 9, anal area 7, 8 and 13 (see Bather, Treatise on Zoology, Pt. III, Echinoderma, London, 1900, p. 68, fig. 3).

Definition.—Callocystinæ? having a depressed globular theca with a deeply invaginated base, and composed of 24 plates arranged as follows:

Basal row has plates 4, 1, 2, 3.

Second row has plates 10, 5, 6, 12, 7, 8, 14, 9.

Third row has plates 16, 11, 17, 18, 13, 19, 15.

Fourth row has deltoids 20, 21, 22, 23, 24.

Anal area bounded by plates 7, 8 and 13.

Pectinirhombs normally situated, small, discreet, and with but few dichopores.

As all the specimens are internal casts of the theca, the nature of the ambulacra, anal area, sculpture and column cannot be given.

Genotype, *Hemicosmites subglobosus* Hall.

The above definition shows that *Coelocystis* differs widely from *Sphaerocystites* in that it has 6 additional plates and that these have quite another arrangement. The second row of the former genus has all the plates of the latter and in addition plates 10, 12, and 14; the third row has 7 plates and takes in all the plates of the fourth row in *Sphaerocystites* while the deltoids of the fourth row in *Coelocystis,* 5 in number, are not present (except 21) in *Sphaerocystites.*

A comparison of the definitions here given with that of *Sphaerocystites* Jaekel (not Hall) shows that the latter omits plate 10 in the second row and has 6 plates in the fourth row against 5 seen in three examples in the National Museum. Both definitions, however, have 24 plates, but these are somewhat differently arranged. The writer's material is excellent and while there is considerable difference in the shape of the plates in different specimens, yet there seems to be no error in the interpretation of their arrangement here given.

Pseudocrinites gordoni n. sp.

Length of the largest theca 32 mm., greatest width 32 mm., depth 21 mm.

Ambulacra angularly elevated, prominent, extending around the entire periphery of the theca, and touching the column in specimens 20 mm. or more in length. In some of these mature specimens the ambulacra when near the column are deflected and one or both will pass on the same side for a short distance in front of it. In smaller specimens the ambulacra do not quite attain the column and in one having a thecal length of 15 mm. they stop within 3 mm. of the stalk. In the largest specimen there are 40 brachioles on each side of an ambulacrum while in

one having a thecal length of 15 mm. there are about 21. Length of brachioles not definitely known, but those of the apical region not less than 11 mm., stout and with about 17 pieces in each column. Ambulacral groove wide and covered by a complex series of small and large ambulacralia.

Basal pectinirhomb smallest, having in the largest specimen about 80 grooves, that on plates 12 and 18 about 90, and the one on plates 14 and 15 is the largest with about 120.

Hydropore minute, closely adjoining the madreporite.

Anal pyramid depressed, consisting of 7 somewhat ornamented plates surrounded by a circle of 8 larger plates of irregular size and decidedly sculptured.

Column slender. Length unknown.

Formation and locality.—Common in the Keyser quarries where it was first collected by Robert H. Gordon of Cumberland, Maryland. The species is named for its discoverer in recognition of the very valuable services he has rendered not only as an enthusiastic collector, but also as a careful student of the complicated geology of western Maryland.

Cat. number 35,071, U. S. N. M.

Pseudocrinites stellatus n. sp.

Length of largest specimen, 25 mm., breadth 23 mm., and depth about 15 mm. Mr. Hartley has a specimen 32 mm. long and 30 mm. wide.

Ambulacra well defined, flat-topped, extending around the entire periphery of the theca and touching the column. Parambulacral plates large. Each ambulacrum has about 36 brachioles; in a specimen having a thecal length of 15 mm. there are 24 brachioles. Brachioles not preserved. Ambulacral groove wide, roofed by a median double row of tiny angular ambulacralia arranged in short crescents, and outside of these by a single row of much larger, strongly elevated plates, each one of which is as large as two of the parambulacralia.

Basal pectinirhomb with about 60 dichopores, that of plates 12 and 18 with 80, and of 14 and 15 with 90.

Madreporite quite large for *Pseudocrinites,* but the parietal pore is exceedingly minute.

Anal area small, composed of two circles of plates, the outer one has 7 nodose pieces and the inner depressed pyramid has the same number of plates.

Column slender, but its length is unknown.

Comparisons.—This species is readily distinguished from all other *Pseudocrinites* by the strongly stellate sculpturing of the plates. *P. gordoni* differs further in having many more brachioles.

Formation and locality.—Of this species 3 specimens are in the U. S. National Museum, 7 in Mr. Hartley's collection and 2 in Mr. Gordon's. All are from the quarries near Keyser, West Virginia.

Cat. number 35,069, U. S. N. M.

Pseudocrinites clarki n. sp.

Length of largest theca 44 mm., greatest width 30 mm., depth 22 mm. Length of an average specimen 30 mm., greatest width 22 mm., depth about 16 mm.

Ambulacra in mature specimens very prominent, triangular in transverse section, extending around the entire periphery of the theca and touching the column. In the second largest individual each ambulacrum has about 44 brachioles, but in another mature specimen there are only 32. Brachioles unknown, but apparently more slender than in *P. gordoni.* Ambulacral grooves narrow and covered by highly elevated ambulacralia of about the same nature as in *P. gordoni,* but less numerous and the larger plates more nodose.

Basal pectinirhomb in the specimen of average size above mentioned, with about 42 dichopores, the one of plates 12 and 18 with about 50, and the one of plates 14 and 15, which is the largest, with about 68. In the largest specimen there are as many as 120 in a rhomb.

Hydropore minute and closely adjoining the rather large and prominent madreporite situated as usual in *Pseudocrinites* laterally between the ambulacra on the edge of plate 18.

Anal area well marked, consisting of two circles of plates. The outer circle has four small plates in the right-posterior corner and these are followed on the left by three very much smaller pieces. The latter are not readily seen and the first impression is that the four pieces of the right-posterior corner and plate 13 complete the circle. The prominent anal pyramid has 7 triangular pieces.

Column stout, composed of thick pieces near the theca. Length unknown.

Comparisons.—This species differs from other *Pseudocrinites,* having ambulacra extending to the column by the regularly oval outline.

Formation and locality.—Of this species the U. S. National Museum has 11 specimens, Geological Survey of Maryland, 1, Mr. Gordon, 2, and Mr. Hartley, 10. All are from the quarries near Keyser, West Virginia. It gives the writer pleasure to name this species for Dr. William Bullock Clark, the distinguished geologist, paleontologist and Director of the Maryland Geological Survey.

Cat. number 35,070, U. S. N. M.

Pseudocrinites perdewi n. sp.

The following four specimens represent four stages in the growth of this species:

	Length	Width	Depth	Brachioles (Total)	Rhomb 1-5	Rhomb 12-18	Rhomb 14-15
Specimen 1	16 mm.	11 mm.	9 mm.	23	20 dichop.	34 dichop.	40 dichop.
" 2	24 mm.	17 mm.	12 mm.	48	42 "	48 "	58 "
" 3	35 mm.	27 mm.	15 mm.	76	53 "	65 "	82 "
" 4	57 mm.	39 mm.	?20 mm.	90	82 "	114 "	148 "

General form pear-shaped with the sides appressed.

Ambulacra wide, very prominent, with vertical angulated sides and flat or slightly trough-shaped oral surfaces. In the specimen numbered 1 the two ambulacra taper rapidly and extend along the periphery of the theca for one-third the length. In number 2, they are just one-half the length, in number 3 nearly two-thirds the length, while in number 4 they are about one-half the length of the theca. This shows that the length of mature ambulacra is somewhat variable, varying between one-half to two-thirds the thecal length. The ambulacrum nearest the anal region is always a little the shorter. Number of brachioles on one side of each ambulacrum varying with age, there being in the youngest known specimen (no. 1) about 5, in a mature individual (no. 3.) about 19 and in the largest example (no. 4) about 22. Ambulacral grooves narrow in comparison with the large size of the parambulacralia, and covered by very small rectangular ambulacralia which are sharply elevated into a median ridge. There are usually from 10 to 12 ambulacralia to each parambulacralium, but in different

specimens the number is variable. The branches going to the brachioles at the lateral ends of the plates have the ambulacralia as well developed as the median series. Brachioles slender, composed of rather large elongated pieces. Those at the distal ends of the ambulacra have 6 pieces in a column 4 mm. long, and seemingly these brachioles did not exceed 6 to 8 mm.

Anal area small, not prominent, and composed of two circles of plates. The outer circle has from 7 to 9 pieces of unequal size and the flat pyramid has 7 or 8 equal triangular pieces.

The madreporite is rather large for *Pseudocrinites,* but the hydropore is minute and both are placed within a distinct hollow separating the ambulacra of one side.

Basal pectinirhomb smallest and that of plates 14 and 15 largest.

Column slender, tapering rapidly for a short distance from the theca and composed of pieces of equal thickness. Length unknown.

Comparisons.—This splendid, large and odd *Pseudocrinites* is readily distinguished from all other species of this genus by the short, high and angulated ambulacra. The form of the theca and the plate sculpturing are also characteristic of this species.

Formation and locality.—Of this form the National Museum has five excellent examples, Geological Survey of Maryland 1, Mr. Gordon 1, and Mr. Hartley 12. All are from the cystid beds of the Manlius in the quarries near Keyser, West Virginia. The specific name is given in recognition of the assistance rendered the writer by Mr. Geo. M. Perdew of Cumberland, Maryland.

Cat. number, 35,072, U. S. N. M.

Camarocrinus ulrichi n. sp.

This species is more pyriform or balloon-shaped than *C. saffordi,* and the theca is usually considerably pinched and prolonged basally into a high collar, evidently for the greater protection of the basal openings. The plates are very much as in *C. saffordi* and where stellation has not set in, adjoin with very finely serrated sutures, but the pores between the plates are much smaller and are far more abundant than in that species. Stellation begins in some individuals by the insertion of small spicular pieces between and around the pore openings and

above the larger plates over the dome of the theca. In different individuals one finds nearly every stage of progression from the non-stellate form to those very prominently stellate.

Young or small specimens of *C. ulrichi* have the depressed form with the large and not sharply delimited basal area of *C. stellatus* showing progressive development towards a more balloon-shaped theca with a pinched and restricted basal termination. The largest known specimen has a diameter of 12 cm.

Formation and locality.—Very common in the lower portion of the Helderbergian (Hunton formation) of Indian Territory where Mr. Ulrich found specimens at many localities for a distance of fifty miles. Some of the best localities are 3 miles north-east and 4 miles south of Daugherty, and 1⅛ miles and 2 miles south of Franks.

It gives the writer great pleasure to name this species for its discoverer, Mr. E. O. Ulrich, one of America's most distinguished paleontologists and an indefatigable collector.

Cat. numbers 35,082—35,085, U. S. N. M.

THE DEVONIAN ERA IN THE OHIO BASIN.*

By Edward W. Claypole.

Part II.

DEVONIAN PALAEONTOLOGY OF THE APPALACHIAN GULF.

The full consideration of the palaeontology of the whole area of the Appalachian sea during the Devonian era would include a study of all the work that has been done in New York and the other eastern states as a standard of comparison, and then similar study of the fossils of the other portions of the basin west and south. Obviously the result would be a treatise far exceeding the necessary limits of this essay. But an attempt will be made to treat with reasonable fullness some of the problems and to give in due detail some of the facts connected with the Devonian history of Appalachian life. It will, therefore, be convenient to treat our subject succinctly under the nine main headings which follow.

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* Continued from page 105.

1. The Invertebrate Fauna of Eastern Appalachia.

The scanty lists of fossils given in the report of the first geological survey of Pennsylvania, and others that have incidentally appeared in those of the second survey and elsewhere, fail to do justice to the abounding life of some of the Devonian beds, which are literally crowded with organic remains. Alternating with these again are beds almost completely barren.

The following tables, drawn up from the writer's own material, nearly every specimen mentioned having been collected by himself, well illustrate both the above statements. Several counties are represented on these lists, from Monroe in the northeast to Huntingdon in the centre, so that no inconsiderable area of the eastern part of Appalachia is covered by the results.

In the examinations of these tables several facts should be borne in mind. In the first place, the Corniferous limestone is lacking over the whole region involved, except in Monroe county, so that the absence of entries on that line has no bearing on the question. Secondly, the separation of the Hamilton into three parts, by the intervention of the sandstone, affords ground for a division of its fossils into the same number of horizons. Of these, the lower shale is remarkable for an almost barrenness of fossils, diligent and continued search having been rewarded by only two or three imperfect specimens. The overlying sandstone is in certain places rich in some forms, one of these a *Rensselaeria* (*Newberria*)—being absolutely limited to this horizon. But the upper shale is one of the most profusely crowded beds wherever it occurs in the region, being comparable only in this respect with the limestone shales of the Silurian below it. This marked difference is not easy of explanation, as the two strata are closely similar in aspect, color, texture and composition. Each of them is about 300 feet in thickness.

The overlying Genesee and Portage shales are again nearly barren but hold their peculiar New York species, with a few others surviving from the Hamilton and even from the Marcellus below them,—the black shale fauna being persistent and recurring with congenial conditions.

In the sandy shales of the Chemung, a profusion of organic remains is found, many of which ascend to high levels, even

reaching the genuine Catskill, but usually occurring in beds of shale intercalated in the sandstone for several hundred feet above its base. It is not possible to set up any dividing plane in middle Pennsylvania between these two groups. The transition is not abrupt. Red sandstones with fish remains, and showing all the typical characters of the Catskill, are followed by shales bearing a Chemung fauna, to be again succeeded by other red beds and so on, through a mass of several hundred feet. Consequently the horizon between the lowest red sandstones with fishes and the highest shale with Chemung fossils is inserted in the tables under the name "Chemung-Catskill passage-beds" and the corresponding fauna, is likewise intermediate in its affinities.

Returning to the base of the column, the presence of a Marcellus limestone is noted. This is a highly calcareous shale and in some parts, a truly argillaceous limestone, not however rich enough to be burnt for lime. It lies at the base of the Marcellus shale and to the west becomes more massive. In some places it may be seen in layers eight to twelve inches thick separated by a few inches of black shale. Ten or fifteen feet of such alternating strata occur in some quarries. To the eastward the limestone diminishes. This series is here assigned to the Marcellus, because the greater part of its scanty fauna belongs in that horizon. But there is more than a possibility that it may represent the shore deposits of the Corniferous sea when the shale was beginning to overpower the calcareous matter and the Marcellus period was approaching. In that case it may be a relic of the home of the shale fauna—the area in which they lived during the prevalence of uncongenial conditions in the clear waters of the Appalachian gulf—a relic of a once more extensive stratum along the Atlantic seaboard which has been almost entirely folded and destroyed by the stupendous changes that have since come over the region.

Perhaps the lists here given might be greatly extended did time allow more work upon the strata. Although far from exhaustive, they will serve to show, when set by the side of the corresponding tables from Ohio, the great contrast between the faunas of the eastern and the western shores of the gulf of Appalachia.

Bibliographical References for the Tables.

Ohio, etc.

a—Palaeontology of Ohio, Vols. I and II.
b—Bulletin of the National Institute.
c—American Geologist, 1893 &c.
d—Palaeozoic Fishes of North America, Monograph.
e—Annals of the New York Academy of Science.
f—Palaeontology of Ohio, Vol. III. in Geol. of O., V. VII.
g—Bulletin 16 of the U. S. G. S.
h—American Journal of Science, 1884.
i—Contribution to Canadian palaeontology, 1893.
j—Zeitschrift der deutschen geologischen Gesellschaft.
k—Proccedings of the Am. Philosophical Society, 1883.
l—35th Report of the N. Y. State Museum of Natural History.
m—Journal of the Acad. of Nat. Sc. of Philadelphia, II, 3, 164.

Pennsylvania.

Report B—Bradford Co.
Report C—Columbia Co.
Report H—Huntingdon Co.
Report M—Monroe Co.
Report P—Perry Co.
Report S—Snyder Co.

	Oriskany.	Corniferous.	Marc. Limestone	Mar. Blk. Shale	Ham. Lower Sh.	Ham. Sandstone	Ham. Up. Shale	Genessee.	Portage.	Chemung.	Chem.-Catskill.	Catskill.
3RACHIOPODA.												
zac H.						P	H.M.P.					
socostalis H.										B.C.H.P.		P
;ostrialis H.						P	H.M.P.			B. C. P.	P	P
cronata H.					P	P	H.M.P.					
juncta Sby.										B.C.H.P.	P	P
dialis H.						P	P					
icosta Con.				H								
minata Con.						P	P					
briata (conradana) H.							H.M.P.					
uxemi H.							P					
yteines & fornacula H.							M					
ecta H.	C. H. P.											
lamellosa H.	C											
nosa Con.	C											
nulifera H.						P	H.M.P.					
vis H.										P		
ı perplana Con.			P			P	M. P.			C. P.		
nervosa H.										B. C.		
parva.										B		
concava H.							H. P.					

	Oriskany.	Corniferous.	Marc. Limestone	Mar. Blk. Shale	Ham. Lower Sh.	Ham. Sandstone	Ham. Up. Shale.	Genessee.	Portage.	Chemung.	Chem.-Catskill.	Catskill.
Strophodonta demissa Con.			P				M. P.			P		
" inaequistriata H.							M. P.			P		
" cayuta H.										B. C.		
Strophomena rhomboidalis W.						P						
Orthis penelope H.						P	P					
" impressa H.										C. H. P.	P	
" vanuxemi H.							M. P.					
" solitaria H.			P									
" musculosa H.	C											
" carinata? H.									P			
" tioga? H.									C P			
Leiorhynchus multicostatum H.				P			M. P.					
" quadricostatum Van.							P					
" limitare Van.			P	H. P. M.	P							
" mesocostale H.										C. P.		
" globuliforme Van.										P		
Atrypa reticularis L.			P	P			M. P.			B.C.H.P		
" impressa H.						P	P					
" aspera Sch.										B. C.		
" spinosa H.							P			B		
" hystrix H.							P					
Ambocoelia umbonata Con.			P	H		P	C. H. P.	H ?				
Ambocoelia umbonata v.										B. C. H.		
Rhynchonella horsfordi H.						P	P					
" contracta H.										B. P.		
" congregata, Con.						P	P					
" prolifica H.							P					
" stephani? H.										B		
" sp.										B. C.		
Tropidoleptus carinatus Con.						B	H.M.P.					
Chonetes setigerus H.				H		P	H.M.P.			C		
" lepidus H.							P		P ?	C. B.?		
" coronatus H.						P	H. P.					
" mucronatus H.			H	H.M.			P					
" logani v. aurora H.							P					
Merista lata H.	C											
Lingula spatulata Van.				H			P					
" ligea? H.											P	
Discina minuta H.			P									
" media H.				H								
" seneca H.							C. P.					
" ampla H.	C											
Streptorhynchus chemungense.												
v. perversum H.							P					
v. arctostriatum H.							P			B		
Vitulina pustulosa H.							H. P.					
Eatonia peculiaris Con.	H											
Cystina hamiltoniae H.							M. P.			C. P.?		

	Oriskany.	Corniferous.	Marc. Limestone	Mar. Blk. Shale	Ham. Lower Sh.	Ham. Sandstone	Ham. Up. Shale.	Genessee.	Portage.	Chemung.	Chem.-Catskill.	Catskill.
Pholidops hamiltoniae H.							P					
Leptocoelia acutiplicata Con.			P									
" flabellites Con.	C											
Productella truncata H.							P					
" spinulicosta H.							P					
" hirsuta H.										C. H. P.		
" " v. rectispina H.										C		
" lachrymosa Con.										B		
Nucleospira concinna H.										H. C.		
Crania hamiltoniae H.							P					
" leoni? H.							P			P		
Cryptonella rectirostra H.							P					
" planirostra? H.							M. P.					
" eudora H.										B. P.		
Terebratula lincklaeni H. (Cryptonella.)							P					
Athyris spiriferoides Eat.							C. H. P.					
Rensselaeria ovoides, Eat.	H											
" ovalis H.	C											
R. newberria claypolii H.							P					
Nucula bellistriata Con.				H			C. H. P					
" corbuliformis H.							C. H.			C	P	
" lineolata H.										C		
" (Leda) brevirostra H.											P	
" randalli H.							P					
" lirata Con.							P					
" varicosa H.							C					
" (Leda) diversa H.									P			
Nuculites oblongatus Con.							C. H. P					
" triqueter Con.							H. P.					
" elongatus.										C		
" cuneiformis Con.							P					
LAMELLIBRANCHIATA.												
Palaeoneilo emarginata Con.							P					
" tenuistriata H.							P					
" filosa Con.							C. P.					
" fecunda H.							H. P.					
" muta H.							P					
" maxima Con.							P					
" plana H.							P					
" barrisi? Sp.												P
" constricta Con.							C. H. S			C. P.	P	
" brevis H.							C			C		
" tenuistriata H.							H. S.					
" perplana H.							H					
Eodon bellistriatus Con.							C. H. P			C. P.		
" tenuistriatus H.							P					
Paracyclas lirata, Con.							P					
Sanguinolites truncatus Con.							P					
" solenoides H.												
" chemungensis.												P
Goniophora ahmiltonensis, H.							P					

	Oriskany.	Corniferous.	Marc. Limestone	Mar. Blk. Shale	Ham. Lower Sh.	Ham. Sandstone	Ham. Up. Shale.	Genessee.	Portage.	Chemung.	Chem.-Catskill.	Catskill.
Goniophora undata H.							P					
" truncata H.							P					
" chemungensis Van.												P
Modiomorpha concentrica Con.							C. H. P.			C. P.		
" alta Con.							P					
" complanata H.							H. P.					
" subalata? Con.											P	P
" quadrula H.											P	P
Orthonota carinata Con.							P					
" undulata Con.							P					
" parvula H.							P					
Macrodon hamiltoniae H.							P					
Cypricardinia indenta Con.							H. P.					
Grammysia cuneata H.							P					
" elliptica H.										B. C.	P	
Modiola metella H.												P
Schizodus rhombeus H.										B	P	P
" cuneus H.												P
" chemungensis Con.										P		P
" oblatus H.												P
" quadrangularis H.										P	P	
Cardiola speciosa H.							C. S.	H	P			
Lunulicardium fragile H.				H. P.			H	H	P			
Cardiola doris H.								H				
Cardiomorpha bellatula H.							H					
" cordata H.							H					
" zonata-concentrice H.							H					
" rotunda? H.												
Actinoptera decussata H.							H. P.					
" subdecussata H.							P					
" zeta H.												B P
" perstrialis H.							C			P		
" birostrata.										C		
" epsilon H.										P		
" boydi Con.							P					
Lyriopecten orbiculatus H.							P					
" priamus H.											P	P
" tricostatus Van.										P		
" macrodontus H.										P		
Ectenodesma birostratum H.												P
Leptodesma potens H.												P
" lichas H.											P	
" becki H.										B	P	
" rogersi H.			H									
Limoptera macroptera Con.											P	
Actinodesma subrectum Whf.						P	H. P.					
Pteronites chemungensis Con.										B. C.		
" laevis.			H?				C. H.					
" decussatus.							P					
Aviculopecten pectiniformis Con.										B. C.		

	Oriskany.	Corniferous.	Marc. Limestone	Mar. Blk. Shale	Ham. Lower Sh.	Ham. Sandstone	Ham. Up. Shale.	Genessee.	Portage.	Chemung.	Chem.-Catskill.	Catskill.
viculopecten aequilaterus H.							C					
" scabridus H.							C					
" princeps Con.												P
eiopteria dekayi H.							C. P.			C		
" bigsbyi H.							H					
terinea rigida H.											B	
" flabellum Con.							C					
lyptoderma erectum Wht						P	P					
terinopecten crenulatus H.										C		
legambonia lamellosa H.	H											
GASTROPODA.												
latyceras attenuatum H.							P					
" carinatum H.							M P.					
" symmetricum H.							P					
" magnificum H.	C											
" ventricosum Con.	C											
" tortuosum H	C											
" tenuiliratum H.	C											
oxonema delphicola H.							H. P.					
" terebra H.							H					
leurotomaria sulcomarginata Con.							H. P.					
" capillaria Con.				H			H. P.					
" trilix. H.							P					
ellerophon thalia H.							P					
" patulus H.				H			P					
" crenistriatus H.							P					
" leda H.							H. P.					
" macra H.										C		P
yrtolites pileolus H.							P					
yclonema concinnum H.												P
" hamiltoniae H.							H					
yrtonella mitella H.							P					
CRUSTACEA.												
hacops rana Green.			P				C.H.P.					
almanites calliteles Gr.							C. P.					
roetus macrocephalus H							P					
" haldemani H.			P				P					
omalonotus dekayi Gr.				H			C. P.					
almanites myrmecophorus? Gr				P								
eyrichia punctulifera H				H			C. P.					
Primitia mundula Jones											P	
Kloedonia simplex Jones.											P	
Primitia pennsylvanica Jones.			P									
ollia ungula Jones.			P									
Bythocypris favulosa Jones.			P									
eratiocaris hamiltoniae n. s.							P					
CEPHALOPODA.												
oniatites discoideus H.				H								
" complanatus H.							H	H	P			
rthoceras marcellense Van.				H								
" nuntium H.							P					
" demus H.										P		
" subulatum H.			H					H				

* See AMER. GEOLOGIST, Dec., 1889.

	Oriskany.	Corniferous.	Marc. Limestone	Mar. Blk. Shale	Ham. Lower Sh.	Ham. Sandstone	Ham. Up. Shale.	Genessee.	Portage.	Chemung.	Chem.-Catskill.	Catskill.
ANNELIDA.												
Spirorbis angulatus H.							P					
" spinuliferus Nich.							P					
Tentaculites gracilistriatus H.				P			P					
" attenuatus H.						P						
" scalariformis H.	M											
Styliola fissurella H.				H S				H P	P			
Tentaculites spicula H.										P	P	
Coleolus acicula H.							P		H P	P		
" tenuicinctus H.				P			P					
Conularia continens H.							C P S			P		
PTEROPODA.												
Taeniopora exigna Nich.							C M P					
Stictopora meeki.										B P	P	
Aulopora tubiformis Gold.							M P S		P	P		
Ptilopora striata H.							P					
CRINOIDEA.												
Actinocrinus eucharis H.							P					
Ancyrocrinus bulbosus H.							P					
COELENTERATA.												
Streptelasma ungula H.							P					
" rectum H.					P		P					
Favosites arbuscula H.							M P					
Heliophyllum halli E. & H.							P					
PLANTAE.												
Spirophytum velum Van.							P					
Ptilophytum vanuxemi H.							P					

II. THE INVERTEBRATE FAUNA OF WESTERN APPALACHIA.

The poverty of the fauna of the western shore of the Appalachian gulf as represented by its fossils (the Corniferous limestone excepted) is in strong contrast with the richness of that of the eastern margin as exemplified in middle Pennsylvania and New York.

Excluding the Corniferous limestone, lists of whose abundant fossils have been published in the reports on the geology of Ohio, the catalogue of fossil Invertebrata from the strata of the region is excessively poor and looks yet poorer by contrast with the rich fauna of some of the homotaxial beds in the east.

The scanty tables given here include all, or very nearly all, that have been reported to date. A few species may have been accidentally omitted, as the literature of the subject is widely scattered and some articles may have been overlooked. Most of these few species are represented by few specimens and these

can be found in but a few places. Personally, in all my field-work in the Cleveland shale, for example, I have seen but a handful of imperfect specimens of *Eodon bellistriatus,* most of which were gathered by Dr. Clark in his labors on the fossil fishes. He has also now in his possession a large cephalopod like Gyroceras undulatum, but not yet described. The utter barrenness of these massive shales must be seen to be fully appreciated.

FOSSILS OF THE OHIO SHALE.*

	Huron Sh.	Erie Sh.	Cleveland Sh.	Bedford Sh.
Conularia sp.			I 486	
Tentaculites fissurella	III 14 II 647			
Coleolus acicula (Orth.)	I 154 III 14			
Macrodon hamiltoniae				II 91
Lunulicardium fragile	VII 506			
Palaeoneilo bedfordensis				P II 298
Avicula speciosa		III 14		
Microdon bellistriatus				VII 507
Leda diberoa v. bedfordensis				VII 507
Euomphalus sp.		I 166		
Pleurotomaria sulcomarginata				VII 507
Bellerophon newberryi				VII 507
B. lineatus				VII 507
Goniatites sp.	II 215			
Goniatites complanatus (Cly.)	I 154			
Platycrinus bedfordensis		P II 161		
Malocrinus bainbridgensis	P II 160			
Ceratiocaris?		I 167		
Ceratiocaris sp.		I 167		
Lepidodondron sp.	II 215			
Calamites sp.	II 647			
Fossil wood	II 647			
Palaeoniscid scales			II 93	
Lingula sp.			II 93	
L. cuyahoga H.				II 91
L. melie H.			III 642	VII 507
L. spatulata v.	Ind. III 14			
Orbiculoidea newberryi				VII 507
Discina sp.?			II 93	
D. newberryi H.			I 686	
D. lodensis v.		VII 506		

* References are to "*Geol. of Ohio,*" vols. i, ii, iii, and vii, and "*Pal. of Ohio,*" vols. i, P. ii, P.

	Huron Sh.	Erie Sh.	Cleveland Sh.	Bedford Sh.
Chonetes lepidus H.	Ind. III 14			
Ch. scitulus H.				VII 507
Ch. logani N & P.				II 91
Ch. speciosus.	I 154			
Orthis tioga H.		I 166,190		
O. vanuxemi H.				VII 507
O. michelini L'Eu.				II 91
Leiorhynchus mesocostale H.		166 I 190 488		
Leiorhynchus newberryi H. & W.		I 166,487		
L. limitare v.		VII 507		
L. quadricostatum v.	Ind. III 14	154 I 166 488		
L. multicostatum H.		I 526		
Ambocoelia umbonata C.				VII 507
Spirifera verneuili disjuncta, Sby		I 190,526		
Sp. alta H.		166 I 190 688		
Sp. disjuncta Sby.		166 I 197 488		
Rhychonella sagerana W.				II 91
Hemipronites crenistria Ph. (Streptorhynchus crenistriatum) Ph.				II 91
Spirifera solidirostris Wh.				II 91
Syringothyris typus W.				I 209 526 II 91
Productella speciosa H.		I 166		
Meristella sp.		I 166		

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Latest and Lowest Pre-Iroquois Channels between Syracuse and Rome. By HERMAN L. FAIRCHILD. From the 21st Report, for the year 1901, of the N. Y. State Geologist, F. J. H. Merrill. Pages r33-r47; with four folded maps, and plates 11-31 (views from photographs). Albany, N. Y., 1903.

Progress in the exploration and correlations of glacial lakes and their outlets in New York is here reported, mapping and describing the

courses of drainage adjoining the border of the receding continental glacier, whereby the former vast lake Warren was succeeded by the Niagara river and falls and by lake Iroquois. While the southern side of the old stream channels was the land slope rising from the Ontario basin, the northern side in numerous places and for long distances was the front of the departing ice-sheet. These latest outflows from the lakes held by the ice barrier farther west passed to the Mohawk valley and the lake Hudson-Champlain by courses only slightly higher than the ensuing lake Iroquois, which outflowed into the Mohawk river across the col at Rome, N. Y., the lowest between the highlands of southern New York and the Adirondack mountains. The maps and views here presented bring most vividly before us a part of the grand changing scenes of the closing stage of the Glacial period. W. U.

The Mesabi Iron-bearing District of Minnesota. C. B. LEITH, U. S. Geol. Sur., Mon., vol. 43, pp. 316, pls. 33, map, Washington, 1903.

This valuable and highly interesting memoir, the fourth of the series on the lake Superior iron districts by the United States Geological Survey, has been awaited with lively anticipation. Being the pronouncement of the chief authority on one of the most important geologic provinces of the United States, the conclusions at which the author has arrived carry with themselves great influence and will have a wide and favorable reception.

The author treats the Mesabi district in a thorough manner. He goes into some detail in the subdivisions of the formations, following, for the general nomenclature the terminology which has been applied by the U. S. survey to the lake Superior region in general, and applying local new terms to the subdivisions. These subdivisions, though previously known and noted, had not been specially named. The excellent map of the Mesabi district which accompanies the volume indicates the attentive and detailed care with which the boundaries of the formations have been traced out; and still more detailed maps, both topographical and geological, are presented of certain localities where greater economic interests are involved.

After a synoptic statement of early exploration, of earlier literature, of the discovery of the ore and of the recent great economic development, the volume enters upon the actual geology, describing in succession the Archean, the Lower Huronian, the Upper Huronian, the Keweenawan, the Cretaceous and the Pleistocene. The term Archean is restricted to the Lower Keewatin, and the Upper Keewatin is termed Lower Huronian, while the Animikie, or iron-bearing rocks, is classed as Upper Huronian. This criss-cross of nomenclature is justifiable, perhaps, from the inflexible standpoint of consistency of the U. S. Geol. Survey, since this nomenclature has been applied to the same formations on the south side of lake Superior, but it breeds confusion on the north side where the Canadian and Minnesota surveys have long used these terms in other senses. The description of the "Archean" makes it essentially an igneous formation, largely composed of greenstone The Lower

Huronian is characterized by a great conglomerate which lies on the "Archean," but above the conglomerate, as described by the Minnesota survey, are great thicknesses of finer detritals. The Upper Huronian (i.e. the Animikie) is divided into three parts. To the lowest part the term Pokegama quartzyte is applied, having a thickness from zero to 500 feet. This is the term used by the Minnesota survey for the same formation. Next higher is the Biwabik, or iron-bearing member of the Animikie, and above that is the Virginia slate. An important fact is emphasized here by the author, viz: the non-conformity of the Biwabik member on the Pokegama quartzyte. This had been noted by the Minnesota survey (by Spurr), but its generality and significance had been overlooked. At the base of the Biwabik is a series of "conglomerates and quartzytes," from a few inches to fifteen or more feet in thickness, which pass upward into the ferruginous rocks of the Biwabik rather abruptly. The relations indicate a brief erosion interval between the Pokegama and the Biwabik. The average thickness of the Biwabik is estimated at 1000 feet, but the actual thickness varies from 200 to 2000 feet.

The Virginia slate is apparently only an upward and very extended enlargement of slates that begin in the Biwabik. "The slate grades, both vertically and laterally, into the Biwabik formation." It is hence very uncertain where the line separating the two subdivisions should be drawn, either areally or stratigraphically.

The Keweenawan rocks are briefly described in the usual terms. They embrace gabbro, diabase, and granite, all intrusive into the rocks with which they come into contact. In regard to the granite of the Keweenawan the author describes it as forming a part of the Giant's range, and as intrusive into the Animikie. Should this conclusion be sustained by future observers it would be a confirmation of the view of H. V. Winchell that the Giant's range was elevated since the deposition of the Animikie iron ores. Mr. Leith's description of the intrusive contact of the granite on the slates of the Animikie is not sufficiently conclusive. It appears to the writer that, though there are two dates of granite in the Giant's range in the vicinity of Birch lake, as fully identified and described by him, yet they may both antedate the Animikie. Some of the facts mentioned by the author as indicative of intrusive action are clearly and necessarily to be referred to fragmental contact at an unconformity of the Animikie on the Archean, and that fact throws a doubt on his interpretation of the rest.

The Cretaceous, which exists on the Mesabi range in isolated areas, is also described. In respect to the Pleistocene deposits, the author states: "Several remarkable steep-walled gorges through the crest of the Giant's range at high elevations are believed to be the work of Glacial streams escaping from a great lake ponded between the Giant's range and the ice-front when the glacier had drawn back from this area."

The most interesting chapters, and those in which the author has shown skill in observation as well as accuracy in description, are those

relating to the features of the ore deposits themselves, and to the origin of the ore masses. Accepting the conclusions of the Minnesota survey as to the primal source of the ore, so far as it can now be actually traced, namely a *green sand* whose disintegration has given rise to the two chief elements in the ore, (hematite and quartz) he nevertheless fails utterly to give any positive explanation of the origin of this sand, though some halting hypotheses are offered supported by some assumptions. This sand was supposed by Spurr to be of the nature and origin of glauconite, and by Winchell to be more or less altered obsidian sand. Nothing can be considered demonstrated as yet to the satisfaction of geologists as to the origin of this "ferrous silicate," and it will probably remain for some years one of the unsolved problems of the lake Superior iron ores. The following quotation expresses the author's belief:

"The iron ore was carried to the Upper Huronian ocean in solution, probably as carbonate, was precipitated as ferric hydrate, was buried with the vegetable material and reduced to the protoxide form, and was then combined with silica to form ferrous silicate. In the Gogebic district where silica was not present in so great abundance, the protoxide combined for the most part with carbon dioxide to form iron carbonate. The shapes of the granules may be due to replacement of minute shells, such as those depositing glauconite, or those giving shape to the granules of much of the Clinton ore."'

That is a pretty long and complicated cycle of hypothetical chemistry, involving hypothetical physical changes.

Mr. Leith names this greensand *greenalite.*

Two chapters are devoted to matters of immediate economic interest, such as distribution, transportation, production, reserve, ownership, prices, methods of mining, and guides to future exploration. All in all the book is a welcome addition to the literature of the lake Superior ores.

N. H. W.

Kansas Glaciation and its Effects on the River System of Northern Pennsylvania. By EDWARD H. WILLIAMS, Jr. Proceedings of the Wyoming Historical and Geological Society, vol. VII, 1902, pp. 21-28, with six plates.

The oldest till in north central Pennsylvania overlies the eroded and smoothly planed outcrops of coal beds, which have been scarcely affected by chemical changes due to infiltration of water through the porous till, indicating that no very long period has elapsed since that earliest recognized stage of glaciation.

Professor Williams here maps a glacial lake that occupied the valleys of Bald Eagle creek and the West branch of the Susquehanna from near Tyrone northeast to Williamsport, having a length of about seventy miles and a width varying from one to five or six miles, with several large bays in the mountain valleys on either side. It is named lake Lesley, in honor of the late J. Peter Lesley, who directed the Second Geological Survey of Pennsylvania.

Other effects of the continental ice-sheet and its drift deposits, in changing the courses of drainage tributary to the Ohio river and lake Erie, are also described and mapped.

This paper, with its admirable illustrations, is an important contribution to glacial geology, and reflects much credit on the local society by which it is published. (A second geological paper in this volume contains records of the earliest use of the anthracite coal of Pennsylvania, by blacksmiths about the year 1770, and in grates for domestic heating in February, 1808.) W. U.

More Concerning the Lansing Skeleton. By LUELLA A. OWEN. The Bibliotheca Sacra, vol. LX, pp. 572-578, July, 1903.

The author thinks that the loess never filled the Missouri valley to the level of the inclosing terraces and bluffs. Her review of the discovery of the Lansing skeleton, and of the discussions concerning its geologic situation and antiquity, indicates the need of further studies of the origin and deposition of the loess, until geolosists shall reach a better agreement. After noticing the numerous papers on this subject, a conclusion is given as follows:

"Professor Winchell's elaborate study of the deposits would seem to demonstrate the existence of glacial man in the Missouri valley beyond all intelligent controversy. On the banks of the Missouri, as on those of the Little Miami and of the Delaware farther east in America, and on the Dnieper in Russia, man was a witness to those great and rapid changes of terrestrial conditions connected with the closing stages of the Glacial period; thus anew raising glacial geology to a most important rank among the historical sciences." W. U.

Guelph Fauna in the state of New York, JOHN M. CLARKE and RUDOLF RUEDEMANN Memoir 5, New York State Museum, Albany, N. Y., 1903.

This volume gathers into one presentation what is known of the Guelph fauna of New York. The Guelph seems to extend from far north and northwest in Canada through Ontario to New York state. It is also found in northern and southern Ohio, in Illinois, Wisconsin and in Iowa. Its westward extension is not known, but it probably does not continue far west of the Mississippi river.

The authors, following Hall, consider the Guelph as a period of incipient desiccation introductory to the salinity of the more complete isolation exhibited by the Salina: marked by numerous corals and coral reefs, by large and heavy shells and by fewness of lamellibranchs and brachiopods.

Discovered first by Hall, in New York, it was named in Canada by Bell, where its development is greater.

We notice that in discussing the Guelph of Illinois, the authors have failed to mention the "Enumeration of fossils collected in the Niagara limestone at Chicago, Illinois with descriptions of several new species," by Prof. A. Winchell and Prof. O. Marcy (Mem. Boston Society Nat. History, vol. I, pp. 81-112, with two plates of fossils, 1865). These

fossils were from the suburb known as Bridgeport.. "The whole mass of the rock is a congeries of organic remains, three-fourths of which are reduced to an unrecognizable condition, and many of which have been totally or partially dissolved out showing, in some instances the delicate tracery of the exterior, or complicated internal structure, in an extraordinary state of preservation." The authors detected 82 species, and McChesney had already described five others, making 87 from a single quarry. With the approval of Prof. Worthen, they refer the Bridgeport and the Racine limestones to the same horizon as the Leclaire, and they, (with him) make the whole a western representative of the Niagara limestone proper, the westward extension of the Canadian Guelph not at that time having been recognized, and not admitted by Hall. Nothwithstanding a difference in fossil species, there seems now but little doubt, from the striking lithologic similarity and from the recognition of similar characters in the Racine limestone of Wisconsin, that the Bridgeport limestone is a western phase of the Canadian Guelph, but probably belonging near the bottom of that formation, at a position where the desiccation had not progressed so far as to expel many of the Niagaran species. The comminution of the most of the fossils also implies the reef-like conditions which are characteristic of the Guelph. N. H. W.

Geographen-Kalender. HERMANN HAACK.. Gotha, Justus Perthes, 1903.

This catalogue contains a *kalendarium* for 1903 and 1904, with an astronomical *Anhang*, by Paul Lehmann; Weltbegebenheiten, 1902, by Paul Langhans; Geogr. Forschungreisen, 1902, by Hugo Wichmann; Geographische Literatur, 1902, by Wilhelm Blankenburg; Bericht über die Schul-geographie, 1902, by Dr. Haack; Die Toten, 1902, by Dr. Haack; Statische Mitteilungen über alle Länder der Erde, by Dr. Haack; Geographisches Addressbuch, by Drs. Haach and Wichmann; Anzeigen, and Kartenbeilagen, by Drs. Haack, and Langhans. These charts inclde late maps of Siam; the railroad from Swakopmund to Windhuk; South Africa; the journey of Prince Henry in the United States; earthquakes and volcanoes in the region of the Caribbean sea; Central America in the region of the proposed canal; Venezuela and the European blockade; Region of the Peru-Bolivia disturbance; The new telegraph-cable in the Pacific ocean;; The expeditions of Sverdrup, Peary and Toll to the arctic regions; Sketch map of south polar expeditions; Sven Hedin's exploration in Thibet; Sarasin's route across Celebes; Pavel and Hösemann's journeys in Kamerun; Routes of Erlanger, Wickenburg and De Bozas in eastern Africa; Tyrrell's examination of the "Barren Grounds" west of Hudson's bay. N. H. W.

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CORRESPONDENCE.

COLUMBIA UNIVERSITY GEOLOGICAL DEPARTMENT.—A highly instructive geological trip and one easy of access from New York city and surrounding points is a walk along the north shore of Atlantic Highlands, N. J., to Sandy Hook. This trip is taken every spring by the palaeontological students of Columbia University. Beginning at the station of Atlantic Highlands and following the railroad track eastward, a very good section of the Monmouth (Up. Cret.) formation is obtained, the railroad making a half cut through it. The lowest division of the Monmouth, the Mount Laurel sands (a coarse red sand) is but several feet thick. The middle bed, the Navesink marls, which are

here the most conspicuous and by far the most fossiliferous, is 40 or 50 feet thick. These marls are very glauconitic. The upper Monmouth, the Redbank sands, are typically red sands, very coarse in places, and form most of the northeastern portion of the Highlands. A few hundred yards east of the station they appear as a conspicuous red stratum capping the bluish-gray Navesink. With a gentle dip to the south-east of about 25 feet to the mile the Navesink descends lower and lower until it finally disappears beneath the railroad track at about a mile from the station, and from here to the Hook the Redbank is alone visible.

Along this cut the fossils are most abundant in the Navesink marls. Perhaps the most noticeable fossil is Baculites ovatus; its large size and unusually well preserved complicated sutures render it very conspicuous. Other large and abundant fossils are several species of Cardium, Turritella and Rostellaria.

Sandy Hook is very interesting from a physiographic standpoint, while two towers for wireless telegraphy and the Sandy Hook lighthouse with its most powerful lights are objects of general interest well worth seeing. (A good description of the Monmouth formation is given by W. B. Clark in Bulletin Geol. Soc. Amer., vol. 8, p. 331.)

H. W. SHIMER.

OBSERVATIONS ON THE GENUS ROMINGERIA BY CHARLES E. BEECHER * —In this article the type species of this genus is discussed together with other species. Billings, Rominger, Nicholson, Davis and Lambe are quoted in order that the "vicissitudes of the genotype may be appreciated." Observations on Romingeria umbellifera are then given, in which greater regularity of growth and budding new cells than heretofore described is shown. Three new species are described, *R. commutata* Beecher, *R. jacksoni* Beecher and *R. minor* Beecher.

This paper deserves further notice, because of the importance of this type of coral among the Tabulata and because of the manner in which the author has treated the subject. Especially his description and illustration of very large fine specimens, are welcome additions to the knowledge of these corals. On the other hand I miss from the article any mention of the parent corallite of the colony and the stolonal beginning. Attention is invited to this omission in view of the future mistake which may very easly arise from it. Where the stolonal or prostrate part of the colony grows much differently from the maturer vertical part these may be mistaken even for different genera, as has been done sometimes in case of Aulopora and certain specimens of Syringopora. In case of a laxly growing colony in Romingeria where there is the probability that accidentally broken off living corallites would plant new colonies the danger of mistakes is, if anything greater.

Nicholson† closes his description of *R. umbellifera* (Bill.) with this remark,—"I think it quite likely that Dr. Rominger is correct

* *American Journal of Science*, vol. xvi, pp. 1-11, plates I-V.

† Paleozoic Tabulate Corals, p. 117

in regarding *Aulopora cornuta* Bill., as really founded upon fragments of the present species. I have, however, various specimens which seem to belong to Aulopora cornuta as regards their general characters, but which agree with Aulopora proper in being parasitic; so that I must at present leave the identity of this form with Romingeria umbellifera an open question." It would be valuable to know what the stolon of the R. umbellifera specimens described by Beecher would have been like.

In Neues Jahrbuch* there is a description of both stolonal and maturer growth of a Romingeria (R. cf. umbellifera). Beecher overlooks this in his review, though his "receipt of your valuable paper" is at hand. Since this paper is not in English it may be well to repeat part of the description here. The best specimen was a silicified colony, the size of a man's fist from Red Rock Pass, Idaho. The cells or corallites grew first horizontally. The mother cell and the bud diverged and each after converging into contact with some other cell once, grew then vertically. New budded cells from vertical mother cells did not form a horizontal stolonal part but grew divergingly upwards.

If Beecher has specimens of R. umbellifera showing the first polyp of the colony and no stolon, this would be an important fact to mention, and in absence of it some conservative feeling is due. His new species may be well founded, even though he may not have followed the same policy with Rominger and Nicholson in this particular case, and yet a person might be permitted I think to urge the advantage of conservative policy with such corals as Romingeria, of which a single species could be expected to build only large regular colonies under most favorable conditions and only smaller, irregular ones under adversity, and for which one locality may well have afforded one condition, and others the different ones.

FREDERICK W. SARDESON.

Minneapolis, Sept. 3, 1903.

Field Geology in Ohio State University. An elective course in Field Geology for upper classmen and graduate students is given each spring term by professor Prosser. The course, which is designed to acquaint the student with the methods of field investigation, requires field and laboratory study of the geological formations of Ohio, and involves the collection and identification of rocks and fossils, the measurement of sections, and the preparation of a report describing the localities studied. In connection with this work not a little addition has been made to the knowledge of the stratigraphical geology of Ohio. For the last term sixteen students registered in the course, every Saturday was spent in the field, and, with the exception of the Waterlime, every formation in the state from the top of the Richmond into the lower part of the Conemaugh was studied in the field.

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* *Neues Jahrbuch für Mineralogie, Geologie und Palaeontologie Beil.-Bd.* x, p 327.

The formations exposed in the vicinity of Columbus were studied first and later those which occur at a distance from the city. The Cincinnati anticline gives the rocks of western and central Ohio an eastern dip and therefore older formations occur to the west of Columbus and later ones to the eastward. The following are some of the more interesting localities studied together with lists of the formations shown: South of Yellow Springs at Goe's Station the upper shales of the Richmond, mottled clays of the Saluda, Belfast bed, and Clinton limestone are well shown in a small ravine near the former residence of Mr. Goe. At Yellow Springs the top of the Clinton limestone is found in the creek of that name, while the bank of Cascade Glen affords an interesting exposure of the Osgood or Niagara shale and further up the run at the Cascade are the West Union, Springfield, and Cedarville limestones of the Niagara series. The best exposures of the last two mentioned formations, however, are to be found in the gorge of the Little Miami river below Clifton, one of the most picturesque localities in southwestern Ohio. The Springfield limestone weathers more rapidly than the Cedarville so that at the contact of the two limestones the latter projects and forms overhanging cliffs. Large blocks fall from these cliffs, one of which lying on edge in the Little Miami river is about 100 feet long, 30 feet high, and 20 feet thick and is known as Steamboat Rock.

Columbus is located on the Ohio shales while a few miles west of the city are extensive quarries in the Devonian limestones. There are numerous outcrops of this limestone, which is divided into Columbus and Sandusky formations. The overlying Olentangy shale is finely shown on the banks of that river and its tributaries to the northwest of Columbus. About ten miles northeast of the city on Rocky Fork is found the top of the Ohio shales, succeeding which are the Bedford shales, Berea sandstone, and Sunbury shale of the Waverly series. The same formations together with the lower part of the Cuyahoga were also studied in the glens near Lithopolis southeast of Columbus where this portion of the Waverly may be seen to excellent advantage. At Newark the upper part of the Cuyahoga is found and the steep cliff and hill expose satisfactorily the succeeding Black Hand and Logan formations, the Sharon conglomerate and as high in the Pottsville formation as the Lower Mercer limestone. This trip affords an excellent opportunity for collecting the fauna of the upper Waverly and the Lower Mercer limestone.

Zanesville, sixty miles east of Columbus, was the easternmost locality studied, but a stop was made at White Cottage, nine miles south of the former city, where the Maxville limestone is finely exposed on Jonathan creek. To the west of Zanesville is a steep cliff called Putnam Hill, and from the bed of the Muskingum river to its top as followed southward are admirably shown all the rocks from the Lower Mercer limestone through the remaining part of the Pottsville formation all of the Allegheny or Lower Productive Coal-measures, into the Freeport sandstone of the Conemaugh formation. At the southern end of the hill in Emery's quarry is the following section: 28 feet of massive

Homewood sandstone, 14 inches of fire clay, 2 feet of Brookville coal with 23 feet of overlying shale before reaching the Putnam Hill limestone. This shale just above the coal contains large numbers of ferns, *Calamite* and *Lepidodendron* stems and some of the tree trunks are still standing upright in the shales. Beneath the coal the roots may be followed for ten feet in the sandstone.

Altogether there are in Ohio some thirty-six formations exposed and the class studied twenty-five of these in the field.

Columbus, Ohio, June 22, 1903. CHAS. S. MEAD.

PERSONAL AND SCIENTIFIC NEWS.

DR. GEORGE P. MERRILL is in the west collecting material from mining camps for the United States National Museum.

PROFESSOR B. SHIMEK of the University of Iowa has recently returned from an extended tour in Texas and New Mexico.

WALTER HARVEY WEED is translating Dr. Beck's treatise on ore deposits, from the German, already in its second edition.

DR. J. EDWARD SPURR of the United States Geological Survey returned recently to Washington via Butte, Mont., after a successful summer's campaign in the mining districts of Tonapah, Nevada. He was accompanied from Butte by his wife and two sons.

A MOVEMENT IS ON FOOT in the state of Nebraska for the erection at Lincoln of a special building for the use of the Historical Society and Geological Survey of the State.

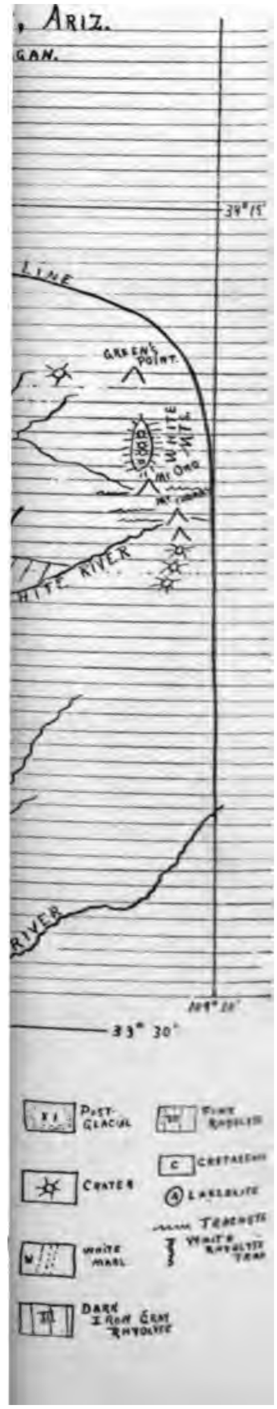
CAPT. R. E. PEARY is preparing to make another expedition to the Arctic regions, having obtained leave of absence for that purpose for three years from the Navy department.

THE STRIKE PREVAILING AT CRIPPLE CREEK among the miners has seriously interfered with the re-examination of that district by Messrs. Lindgren and Ransome, and Mr. Lindgren has gone to Australia.

PROFESSOR HEINRICH RIES of Cornell University spent the summer in Texas, where he was engaged in a study of the clay deposits of that state. The results will be published as a bulletin of the University of Texas Mineral Survey.

WALTER E. HOBBS of Stonybrook, Mass., died at his home recently of tuberculosis contracted through exposure to the germs in Colorado. He had made extended travels in the west, particularly in the mining states, and was preparing to publish his observations.

DR. O. P. HAY, of the American Museum of Natural History, according to *Science*, has made a large collection of fossil turtles from the Eocene (Bridger) deposits of southwestern


ARIZ.
GAN.
34° 15'
LINE
GREEN'S POINT
WHITE MTS.
RIVER
33° 30'
POST-GLACIAL
CRATER
WHITE MARL
DARK IRON GRAY RHYOLITE
CRETACEOUS
TRACHYTE
WHITE RHYOLITE TRAP

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GEOLOGY OF THE FORT APACHE REGION IN ARIZONA.

By ALBERT B. REAGAN, Bloomington, Ind.

PLATES XXIX-XXX.

CONTENTS.

The following pages are derived from studies carried on at intervals during the writer's stay on the White Mountain Apache Indian reservation as government farmer. While there he took work by correspondence in the University of New Mexico; and the original reports on which this paper is based were submitted to Dr. W. G. Tight, president of that university, at whose request this paper has been prepared for publication.

In submitting this paper the writer gratefully acknowledges the personal aid rendered him by Drs. J. W. Beede and F. V. Marsters while the manuscript was being written.

LITERATURE.

Dr. Arch. R. Marvine passed through the region under consideration in 1871 from the Little Colorado river to Fort Apache, then called Camp Apache; and from thence he went via the San Carlos river to the Gila valley. While on this trip he examined the rocks over which he crossed, obtaining sections, and other valuable information. Dr. G. K. Gilbert also visited Camp Apache in 1873. While there he made three side trips; the first to the White mountains or Sierra Blanco country, the second up the North Fork of White Mountain river, and the third to the junction of the main forks of the river. These men both belonged to the U. S. Geographical Survey corps. Their respective reports may be found in Volume III. of the U. S. Geographical Surveys west of the 100th Meridian. A further discussion of the above citations will be given when the respective areas concerned are considered.

GENERAL DESCRIPTION.

The Fort Apache region is in east central Arizona between longitude 109 degrees 30′ and 111 degrees 10′ W; between latitude 33 degrees and 34 degrees 20′ N. Roughly speaking, it is a trapezium in form, its longest line being at the southwest, its shortest on the east. Its margin on the north is formed by the Mogollon range, on the east by the White mountains, on the southeast by Black river and the Nantanes and Apache mountains, and on the southwest by the Pinal and Sierra Ancha mountains and the Tonto basin. It is in the southwestern part of the great Rocky Mountain Plateau district, the fault along the western side of the Apache mountains being the southwestern limit of that plateau.

The region, which is practically impassable except by trail, presents a diversity of appearance. It is a great basin whose rim is the mountains mentioned above. This rim is for the most part from 7000 to 11000 above sea-level, while the centre of the area at the west is only 3000 feet in altitude. Through its centre from the southeast, with a bold curve to the west, passes Salt river, whose tributaries drain the various slopes. To return to the rim, the Mogollon range is an elevated grassy plain, on which are fine forests of pine and fir. The White mountains are a volcanic area from which lavas have flowed

over thousands of square miles covering everything with a lava sheet to the thickness of 3000 feet in many places. The Pinal mountains are a mass of rhyolyte superimposed on Archæan and Primordial rocks. And the Sierra Ancha is a massive squarish steep-sided mesa mountain, composed for the most part of Tonto sandstone. To consider the entire region again it is a much broken country. Besides an intricate maze of small, deep, cross-valley canyons separated by sharp ridges, there are canyons of gigantic dimensions. These have their sources in the mountains, and though practically dry streams now, they testify to the former grand rivers of the area.

The region for the most part is occupied by the White mountain Apache and San Carlos Indian reservations, except at the west front which lies beyond the Indian reserve. The cities are Whiteriver and Fort Apache at the terminus of the Holbrook-Apache wagon road in the White Mountain Apache Indian reservation, Ellison, and Young in the Tonto basin, and Globe, the county seat of Gila county, situated near the southwestern part of the area. This latter place is a mining and business center. Moreover, it has an outlet to the Southern Pacific railroad via Solomonville and the Gila valley by the Gila Valley and Globe railway.

SCENERY.

There are grassy, forest-covered mesas, crossed and barred with deep almost impassable canyons, cut from 1000 to 2500 feet in the Palæozoic and Archæan rocks. There are terraces, precipitous cliffs, lava capped mesas, hog-backs, palisade buttes, and "mauvaises terres;" while volcanic necks in the form of buttes dot the region, and mountains close in the horizon on every side. From an elevated position the scenery is grander still. To stand on the top of the volcanic neck five miles west of Colley's ranch and twenty-three miles a little to the west of north from Fort Apache upon a quiet day, one can look north across the valley of the Little Colorado to the mountains beyond the Indian village of Moqui a distance of one hundred and thirty miles. To the east he can see the continental divide many miles beyond the snow caps of mounts Ord and Thomas of the White mountains. To the south he can see the Gila range and to the west the mountains beyond the Verda river. While to the southwest he can look beyond the Plateau region, even be-

yond the Apache and Pinal mountains to the region of the "lost mountains" of the lower Gila valley. On each side everything is bathed in the most delicate tints and everything lies deathlike in the peculiar intangible afternoon haze of the region which seems to magnify distant details rather than subdue them. The wonderful monotony seems uninclosable in any horizon and one imagines the scene to continue on always the same and without end.

STRUCTURE.

The rocks of the region are intrusive, extrusive, and sedimentary.

The intrusive rocks are the laccoliths, dikes, volcanic necks and intrusive sheets of the region; the extrusive rocks are the lavas and tuffs that overspread the greater part of the country; and the sedimentary rocks, the deposits that were laid down in the seas and lakes in almost continuous series from the earliest known geologic time to the most recent.

The Sedimentary Rocks.—Among the level canyon-cut rocks of the plateau part of the region, the sequence of strata is never lost. Save where covering lavas are crossed, there is no break in the observation. One bed is followed with the eye until it either dips beneath the surface or is ended by denudation and another bearing a definite relation to it is taken up. An unconformity is usually seen at a glance. But in the Apache and Pinal mountain area southwest of the Plateau the case is reversed. The mountains divide the space with the valley gravels and the eruptive rocks serve to mask the sedimentary deposits. The outcrops of the latter are reduced to the condition of peninsulas or islands each of which is a problem in itself.

The dip of all the sedimentary deposits east of the longitude of Canyon creek is north and east. West of that line and north of Salt river the dip is north or north and west, while south of that river the dip swings around from southwest via the south and southeast to a northeast dip.

The geologic systems represented are the following: 1, Quaternary; 2, Tertiary; 3, Cretaceous; 4, Aubery Group; 5, Upper Red Wall Group; 6, Lower Red Wall Group; 7, Devonian; 8, Upper Silurian; 9, Tonto Group; 10, Algonkian; Vol-

canic rocks, shales, etc.; 11, Archæan schists, granites and allied rocks.

STRATIGRAPHICAL SECTIONS.

SECTION I. *Canon creek, Arizona, from the source of the stream to its confluence with Salt river.*

		feet
	Quaternary:	
1.	Coarse uncemented gravel, of gneiss and quartzyte boulders	125
	Aubery Group:	
2.	Calcareous sandstones, followed by soft shales and an occasional limestone stratum	700
3.	Massive, crossbeded yellow standstone	525
	Upper Red wall Group:	
4.	Compact gray limestone	70
5.	Red and purple sandstone	500
	Lower Red Wall Group:	
6.	Alternating gray limestone and red shale	400
	Tonto Formation:	
7.	Sandstone	500
	Algonkian:	
8.	Biotite granite, hornblende dioryte and olivine diabase	800
9.	Limestone with coralloid mottling	50
10.	Shale series: The shales are greenish and purple in color. They are soft and thin and are interstratified with pale red sandstones and an occasional mottled limestone stratum	700
11.	Massive lava bed, crumbling to green sand	100
12.	Vitreous red, heavy-beded sandstone	100
13.	Conglomerate	40
	Archaean.	
14.	Granite and allied rocks	600
	Total thickness of rock exposed estimated as above	5210

SECTION II.. *Canyon creek at the crossing of the government trail, partly measured by aneroid barometer (after Gilbert).*

			feet
	Quaternary:		
1.	Coarse uncemented gravel of quartzyte and gneiss boulders		20
	Aubery Group:		
2.	Massive cross-bedded yellow sandstone		525
	Upper Red Wall Group:		
3.	Compact gray limestone [*Spirifer cameratus*]		65
4.	Red and purple sandstone, soft at top, massive below		500
	Lower Red Wall Group:		
5.	Alternation of gray limestone and red shale:		
	a. Limestone	5	
	b. unseen, shale?	100	
	c. Limestone (*Athyris subtilita*)	10	
	d. Red Calcareous sandstone	4	
	e. Shale	40	

f. Limestone	4	
g. unseen; shale-	25	
h. massive limestone	2	
i. unseen; shale?	75	
j. Limestone	2	
k. unseen; shale?	50	
Total of 5		325
Tonto Formation:		
6. Sandstone:		
a. Brown to red, coarse vitreous, sandstone, massive to shaly	100	
b. Gray fine-grained sandstone, weathering red, falling apart in angular blocks	75	
c. Shaly calcareous sandstone	57	
d. Vitreous, red, purple and white sandstone	150	
e. Coarse siliceous conglomerate	25	
Thickness of 6		425
Archaean:		
7. Hornblendic rock and schists; unconformable		500
Total Thickness of Section		2360

SECTION III. *Section on west bank of Cibicu creek one mile north of farmer's residence.*

Upper Red Wall Group:	feet
1. Hard white limestone, very fossiliferous, fossils of Spirifer family predominating. This limestone is the cap of the first mesa bench west of the creek	12
2. Gray, brown to buff, easily broken, soft limestone (*Productus cora*)	1
3. Sandstone, brown to buff, shaly	10
4. Limestone, brown soft, fossiliferous, Lamellibranch fossils predominating	6
Lower Red Wall Group:	
7. Shaly to massive, rough to the feel, dark-gray, calcareous sandstone often composed in part of lime particles, and the ground up material of other rocks. This is a mill stone grit rock	20
8. Brown sandstone	8
9. Red sandstone breaking down to red earth	40
10. Reddish to brown shale	12
11. Bluish-white, soft limestone in which are Gasteropod and Lamellibranch fossils	4
12. Brown sandstone	6
13. Black shale	2
14. Not seen, shale and sandstone?	25
Total	159

SECTION IV. *In Seven Mile Hill canyon, five miles southeast of Fort Apache, Arizona.*

	feet
Quaternary:	
1. Basalt	200
2. Volcanic ashes	10
3. Strata of mostly unlithified sands and clays	40
4. Shale, light colored, sandy	4
Tertiary:	
5. Conglomerate rock, the cement being volcanic ash. The pebbles and cobblestones of this series are: quartzytes, granite, andesyte rhyolyte, limestone of the Palaeozoic era, etc. (No cobblestone or pebble of the basaltic type was found in this conglomerate).	60
6. Strata of partly lithified coarse grained, reddish to light brown sandstone, composed of angular and rounded grains of granite, rhyolyte, etc. In this series the rhyolyte-trachyte particles predominate	200
Carboniferous:	
7. Red gypsiferous shales, with sandstone and limestone	800
Total	1314

SECTION V. *East wall of Cherry creek canyon, Arizona, seven miles north of Salt river, near Mr. James Hinton's house.*

	feet
Tertiary:	
1. Light brown to dark brown rhyolyte, capping buttes. This rhyolyte is continuous at the base of the butte with that which underlies the Tertiary formation here	30
2. Conglomerate rock, the cement being tufa	80
3. Tufa agglomerate	20
4. Light gray sandstone	10
5. Rhyolyte	30
6. Gray sandstone and conglomerate	100
7. Fine grained, gray to brown sandstone, composed of ground up Archaean and Paleozoic rocks, granite, rhyolytes, diabases, etc.	40
Total	210

SECTION VI. *South of White river, three miles west of Ft. Apache.*

	feet
Quaternary:	
1. Basalt	200
2. Unlithified volcanic ashes	10
3. Loose strata of slightly lithified clays and sands	40
Carboniferous:	
4. Red gypsiferous shales with sandstone and limestone	1000
Total	1250

SECTION VII. *On the Government trail from Ellison's to Canyon creek.*

	feet
Quaternary:	
1. Adobe clay	8
2. Loose cobble stones and pebbles	1

3.	Yellow clays inter-stratified with loose sand	4
4.	Cobble stone stratum	1
5.	Light yellow to pink, lithified, stratified rock, composed of fine grains of Archaean and Tonto rocks	10
6.	Dark brown partly lithified sandstone	1
7.	Yellow to brown and pink cross-bedded sandstone	10
8.	Conglomerate series	20
9.	Porphyry, gneiss and granite rocks (all intrusive)	100
	Tonto:	
10.	Sandstone and shale	500
	Archaean:	
11.	Hornblende biotite granite and olivine diabase and hornblendic dicryte	500
Total		1155

SECTION VIII. *Red Wall cliff east of the Agency at Whiteriver.*

Upper Red Wall Group:

		feet
1.	Compact yellowish gray limestone *(Spirifer cameratus, Productus costattus, P. semirectículatus*	75
2.	Red gypsiferous shales, with limestone and sandstone	800
3.	Gray to white limestone interstratified with red shale *(Productus semireticulatus, Productus cora)*	50
Total		925

SECTION IX. *Tonto bluff, point Chiddesche on Canyon creek.*

Tonto:

1.	Brown to red, coarse vitreous massive sandstone, breaking up in angular blocks	200
2.	Red shale showing cleavage structure	50
3.	Gray sandstone weathering red, falling apart in angular blocks	175
4.	Conglomerate stratum	20
	Algonkian:	
5.	Dark crystalline diabasic lava bed, which rarely forms into cliffs, its rocks crumbling into a light olive-green sand	500
6.	Not seen; shaly sandstone?	80
Total		925

SECTION X. *From Farmer's residence on Cibicu to the Salt Springs on Salt river near its confluence with Canon creek. Upper Red Wall Group:*

		feet
1.	Alternating limestone and sandstone *(Productus cora, Spirifer cameratus, Calamites cannaeformis)*	60 to 120
2.	Millstone grit, calcareous sandstone shaly to massive	20
	Lower Red Wall Group:	

3. Alternating gray limestone and shale varying in color from black to red (*Orthis porcata, Orthis livia, Spirifer fornacula, S. striatus; S. pre-extensus, S. plenus, Orthonota paralleta; Lithostrotion cali*

fornicnse, Chonetes dalmaniana)	400
Devonian:	
4. Alternating chert and flint strata	40
5. Massive light colored marbled limestone, *(Acervularia davidsoni* abundant)	35
6. Stratum of grit rock	15
Silurian:	
7. Red to brown fossiliferous limestone *(Orthis davidsoni, Strombodes pentagouis)*	65
Tonto Formation:	
8. Massive to shaly, brown to red, coarse, cross-bedded viterous sandstone	600
9. Red, Cleavage-jointed shales	40
10. Gray to red sandstone falling apart into angular blocks	70
11. Marbles, limestone	35
12. Vitreous to soft, red, purple, green and white sandstone and shale, a conglomerate completing the series	150
Algonkian:	
13. Hornblende biotite granite and olivine diabase (intrusive) and dioryte	120
14. Vitreous, soft, red, purple, green and white sandstone and shale	300
15. Conglomerate	10
Archaean:	
16. Gneiss	100
17. Granite and allied rocks	600
Total	2635

SECTION XI. *On Corrixo creek (Gilbert).*

Quaternary:	feet
1. Coarse gravel composed of vitreous sandstone quartzyte and gneiss boulders	50
Aubery Group:	
2. Massive cross-stratified, yellow sandstone	150
3. Red and gray shales, interrupted with calcareous beds	400
Upper Red Wall Group:	
4. Dark gray limestone *(Nautilus occidentalis, Bellerophon crassus, Euomphalus (like E. nodus), Machrocheilus, Pleurotomaria, Murchisonia, Allorisma, Aviculopecten interlineatus, Productus smeireticulatus, Archaeocidaris, Fenestella shumardi(?), Galuconome)*	100
5. Alternating cream, or gray and red shales; soft and carved by rain, with vertical flutings	500
6. Bedded red sandstone, shaly at base	200
7. Gray limestone with carnelian, fossils and chert *(Arthyris subtitita, Spirifer cameratus)*	20
Total	*1420

*The age of the rocks is inserted by the writer.

SECTION XII. *North from near Camp Apache (Fort Apache)*
(Gilbert, U. S. Geographical Survey west of the 100th Meridian, Vol. III, p. 165.)

		feet
	Quaternary:	
1.	Basalt and basalt gravel	70
2.	Pale pink slightly coherent, massive sand and gravel resting unconformably on No. 3	520
	Aubery Group:	
3.	Calcareous sandstone:	
	a. yellow	100
	b. red	180
4.	Soft red and gray shales, interrupted by sectile limestone:	
	a unseen; shale?	190
	b. soft red shale	50
	c. gray limestone	10
	d. gray shale	10
	e. yellow limestone	4
	f. red and gray shales	60
	g. gray to cream limestone, with minute fossils	25
	h. red shale	80
	Upper Red Wall Group:	
5.	Fossiliferous gray limestone:	
	a. thick bedded limestone	25
	b. unseen; red shale (?)	25
	c. limestone, sectile to massive, with some chert *(Productus, Bellerophon, Spirifer, Archaeocidaris*	75
6.	Red gypsiferous shales, with sandstone and limestone:	
	a. unseen; shale(?)	160
	b. cream gray thin-beded limestone	15
	c. unseen; shale (?)	85
	d. green gray impure limestone	15
	e. red gypsiferous shale	70
	f. massive gypsum	10
	g. red shale, graduating below to soft red sandstone	240
	h. red and gray shale interlaminated with gypsum	70
	i. calcareous sandstone with prints of mud-cracks	1
	j. red shaly, ripple-marked sandstone, with red-clay shale and red sandy shale	120
	k. unseen; shale (?)	50
Total		*2260

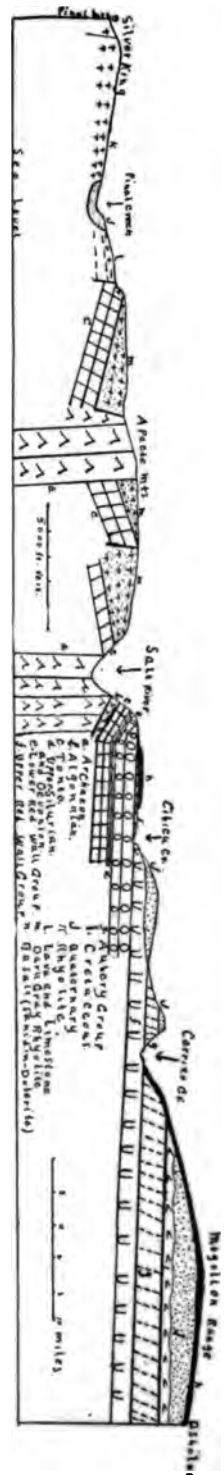
STRATIGRAPHY.

The Archaean.—Archæan rocks form the nuclei and also the crests, and in many places the flanks, of the Pinal and Apache mountains. They are also exposed in many places around the Plateau break. They are the country rocks of lower Canyon

*The age of the rocks given above is inserted by the writer.

creek, of Salt river below the Salt springs, of the middle Cherry Creek valley whete not covered with lava, and of the region between the Tertiary aud the Plateau south of Sombrero butte. They are also occasionally exposed on upper Canyon creek. These rocks represent two distinct systems. The upper one is composed of crystalline schists embracing hornblendic to mica schists. Syenytes are also found in this upper formation. The schists always underlie the later groups. The lower system is granite. This granite except in the Apache mountains is a coarse, granular aggregate of quartz grains, and orthoclase, the crystals of the latter being mostly white, and mottling the weathering rock. The most extended out-crop of this granite that was noticed by the writer is near the confluence of the Canyon creek and Salt river. At this place as in all localities where examined it was found to be characteristically affacted with joints. Mr. Marvine also noticed this peculiar jointing of the granite of the Pinal mountains where he crossed them in 1871 and in writing about it he says the granite "is at first strongly affected with joints having a southern trend, and inclined 60° to 80° eastward with a subordinate system of east and west joints, dipping north, the two together tending to stud the surface with large tombstone like slabs.[4]

The crystalline schists, micaeous, talcose, chloritic, and hornblendic, are extended most in outcrops along the northeast flanks of the Apache mountains from whose crests they continue to and in places beyond Salt



river, where not covered with lava or Quaternary deposits. These schists, wherever exposed, were seen to grade into gneiss and syenyte and these in turn to grade into granite, there being no unconformability between the upper and lower series (the schists and the granite) so far as the writer knows. The Huronian and Laurentian systems may be represented in the Archæan here; but at present, evidence is wanting to warrant such identification.

The Archæan rocks seem to culminate in an east and west ridge beneath the clastic rocks in about the latitude of Ellison. This ridge is not the result of uplift because the clastics all dip to the north irrespective of the ridge. Again the ridge may have existed prior to the deposition of the sediments, because at its crest the Algonkian series is wanting.

The Algonkian.—The Algonkian rocks are exposed along the edge of the southwest escarpments of the Plateau region, in the Salt River canyon from the Pinal mountains on the west to the confluence of Corrixo creek with Salt river on the east, and in the Canyon Creek valley from Salt river north to Chiddessky. It is the country rock of nearly all the mesa between Cherry creek and Canyon creek from the Ellison post office south to Salt river, as well as of the mesa between Canyon and Oak creeks. It is also exposed in the middle Cherry Creek valley and along the east wall of Sierra Ancha. These rocks, in the main, are composed of massive lava flows of the dioryte and diabase types interstratified with sandstones, mottled, coralloid limestones, and many-colored shales. This series is unconformable with the underlying Archæan, and with the overlying Tonto. It begins with a conglomerate, and the Tonto which immediately overlies it is also conglomeratic.

The lost record represented by the unconformity of this series with the Archæan must be very great, at least as great as that represented by the unconformity between the Algonkian and the Archæan in the Grand Canyon series. But the lost record between the Algonkian and Tonto was much greater here than there—indeed so great that the Chuar terrane and the greater part of the Ukar terrane are wanting. These unconformities, besides indicating a lost record, are evidence that this region was a land area both at the close o fthe Archæan

era and for a long time prior to the deposition of the Tonto sediments.

The Tonto Formation.—This formation is composed of coarse to fine grained, often cross-bedded vitreous sandstones and sandy shales, varying in color from brown to red, purple, and white. The formation is the surface rock of a large area. The Sierra Ancha mountains are capped with it. It is exposed all around the rim of the Tonto-Cherry Creek basin and continues on the east from that basin beyond the head waters of Oak creek in the latitude of Chiddessky on Canyon creek. From this point it extends in an ever-widening strip along the Plateau south across Salt river to the Apache and Nantan mountains. Patches of it also occur in the Apache and Pinal mountains. In short the Tonto exposures completely encircle the Archæan and Algonkian areas of the Salt river and Canyon creek region. That it once covered the entire Archæan and Algonkian area is attested by the vitreous sandstone points and buttes scattered over the country, among which are points Chiddesche and the Twin and Sombrero buttes. A further mention of these buttes and of the domed structure which caused the Tonto formation and the formations overlying it to be removed from the Algonkian willl be made when the subject of Physiography is taken up.

The Upper Silurian.—Immediately overlying the Tonto at its outer edge and possibly conformable with it are red to brown fossiliferous, coarse-grained lime rocks having a thickness of about seventy feet.

They form only a narrow band, but are continuously exposed from the Tonto basin to Nantan mountains, where not covered with talus or lava. The best exposures observed by the writer are on the trail to the Salt springs, some ten miles southwest of the farmer's residence on Cibicu, and on the John Dazen trail near the Oak creek break about a half mile southeast of Oak creek cliff houses. This formation is Silurian, at least the fossils obtained, *Orthis davidsoni, Strombodes pentagonus,* etc., seem to bear out this conclusion.

The Devonian.—Immediately overlying the Silurian on the periphery are alternating chert and flint strata followed by massive, very fossiliferous, light colored, fine grained, marble limestone, which in turn is followed by a grit. This formation,

like the Silurian, is exposed as a narrow strip encircling the Ellison dome from the Nantan mountains on the southeast around by the northeast to the Tonto basin where it forms one of the "rim" series of that basin. The strip thus formed is sometimes more than three miles wide, though it is usually much less. Besides this belted strip several of the buttes of the Tonto region belong to this formation, one of which is situated three miles northeast of Ellison. This butte is called Juniper butte on the government maps; but among the settlers it is called Shell mound, because of its numerous shell fossils. The formation is Devonian as is indicated by the fossils obtained, *Orthis livia, Spirifer fornacula* and *Acervularia davidsoni,* and corresponds very much to the Devonian formation at the falls of the Ohio.

The Lower Red Wall Group.—The first series above the Devonian is from 400 to 1000 feet of alternating gray limestone and shale. It terminates at the top in a massive to shaly coarse sand rock, often of the mill-stone grit type. The lime rocks are very fossiliferous from the middle of the series to the top and seem to belong to the lower Carboniferous group; but as yet the writer has not identified fossils enough from the group to verify such a conclusion.

This group of rocks is exposed along the canyon walls of Salt river from its confluence with Cibicu creek east farther than was visited, in the canyon of White river from Fort Apache west to Salt river and in the canyons of Cedar, Carrixo and Cibicu creeks in their lower courses. It is the surface rock for many miles on either side of Salt river east of that river's confluence with Cibicu creek from which place it extends in a wide belt around the Ellison dome to the Tonto basin. The exposures of this series make good soil on which grow the best grass and timber of the western part of the Fort Apache Indian reservation, and the Grasshopper Spring division of it is said to be one of the leading grass producing regions in Arizona.

The Upper Red Wall Group.—The writer has included in this group all of the strata superimposed on the mill-stone grit rock of the group just described, to and including the dark gray limestone series about 1000 feet above its base. The series here is very variable, indicating a rapid transformation from west to east. Ripple marks and old shore lines are noticeable

and indications of large swamp land areas are exposed on Cibicu creek and in the vicinity of Fort Apache. As evidence that the country reached the swamp stage the writer found several specimens of *Lepidodendron,* and one whole tree of the species, *Calamites cannaeformis.* The group belongs to the coal-measure series as is attested by its fossils: *Spirifer cameratus, Productus semireticulatus, P. costatus, Lepidodendron, Calamites cannaeformis,* etc.

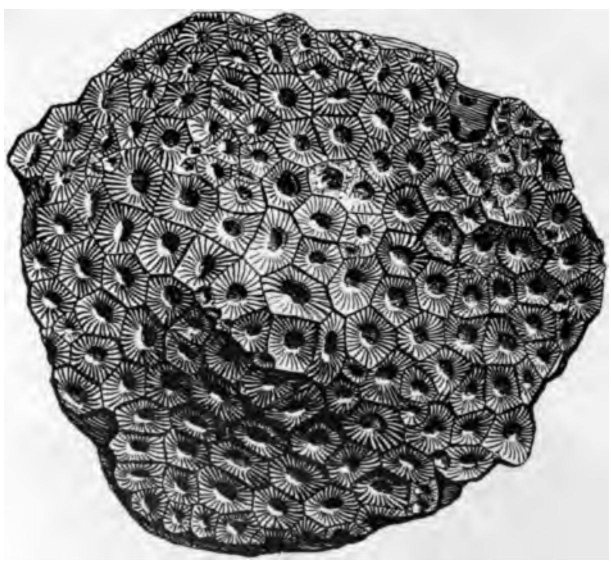
The exposures of this group are restricted for the most part to the bench lands and canyon-like slopes of the inner lowlands of all the streams in their middle and lower courses from the White mountains west to Cibicu, from which place they extend around the Ellison dome in a wide belt to the "rim" of the Tonto basin. The southern prolongations of the Mogollon mesa are also usually capped with this formation near their terminus. Several small patches also occur in the vicinity of Globe.

The Aubery Group.—The interstream spaces of all the streams in their upper course as well as the south front of the Mogollon range and the Cibicu divide, where not covered with later deposits are capped with 280 feet of calcareous sandstone followed by 500 feet of soft red and gray shales, interrupted by sectile limestone. The Aubery limestone occurs in one locality—at the head waters of the Cibicu and Canyon creeks. The rocks of this group are usually non-fossiliferous; but fossils enough were obtained [*Athyris subtillita, Productus punctatus, Spirifer cameratus, Productus,* and *Bellerophon*] to identify it as upper Carboniferous.

The Cretaceous (?). About twenty-six miles northwest of Fort Apache near Forestdale a coal outcrop is exposed, which seems on lithological grounds, to be the same as the Fort Union or Laramie coal of New Mexico. The extent of this coal series is not known to the writer as it is almost everywhere covered with later deposits.

The Tertiary.—After the deposition of the Laramie the country was elevated and much eroded. Then another period of deposition set in, the deposits of which correspond in lithological character to the late Tertiary of New Mexico, though it is quite possible that the period of deposition covered a much longer time. It is quite probable that the deposition has, in the

Escarpment east of Canyon Creek, showing the dip of the strata.



Acervularia Davidsoni EDWARDS & HAIME. (For a description see the 11th Annual Report of the Indiana Department of Geology and Natural History, page 386). Location: On the Government trail, four miles east of Canyon creek, Ar.; on the John Dazen trail, ¾ mile southeast of the Cliff houses near Oak creek, and along the Rim of the Tonto basin, Arizona.

Seven-Mile hill section and in the Salt river and Hinton regions, accumulated through the Tertiary and may have begun even earlier. The Tertiary rocks begin with a consolidated, coarse, conglomerate series, beneath which are strata of partly lithified to lithified sands, clays and gravels reaching a thickness of nearly a thousand feet in most places. The formation is found, for the most part, in the ancient canyons of the region and indicates a laking stage, caused by the seismic disturbances during the Tertiary. These will be further considered under the next subject.

The Quaternary.—Conformably superimposed on the Tertiary are hundreds of feet of unconsolidated gravels and clays and occasionally volcanic ashes. This series covered the entire region, except possibly the Ellison dome, so that the lava flows which closed the epoch flowed over a plain. Since then much of it has been removed so that now it is patchy except where protected with superimposed lava. It now fills all the valleys in the Pinal and Apache mountain districts; the volcanic and plutonic rocks projecting above it as peaks and mountain ridges. The middle Cherry Creek valley and the Tonto basin, as well as the Ellison flat, are covered with it. It covers the Mogollon mesa together with its southern prolongations to a thickness of from 500 to 1000 feet. It is the surface rock of the Kelley butte country, and extends beneath the lava of the Nantan plateau as far as visited.

Cause of the Deposition of the Quaternary and Tertiary deposits.—It was found on observation that the gravels and cobble-stones of the Tertiary and Quaternary formations were: schists, quartzytes, gneisses, Carboniferous rocks, vitreous Tonto sandstone, diorytes, trachytes and Archæan rocks. The first opinion of the writer was that the formation was of glacial origin; but careful examination showed no striæ markings. Moreover, many of the rocks were found to be angular and not much if at all water worn. So the glacial origin theory had to be abandoned.

The next feasible theory that suggested itself was that of depression, but since the Salt river, Hinton, and Globe deposits are 4000 feet below those on the Mogollon range yet no indication of a brackish or salt sea is to be found in them, it was necessary to abandon the depression theory also.

The depression theory being abandoned, the land-barrier theory was suggested and on investigation it seemed to solve the problem. The country was as high in Tertiary and Quaternary time as now; but great barriers blocked the waterways and changed the course of the streams of the country. At the close of the Laramie as we shall show when the subject of Physiography is taken up, the whole region was greatly elevated above the sea and the streams cut great canyons. In this period Cibicu creek, which now has but little water in it, was a large river, which flowed not southwest as it does now in its lower course, but in a southeastern direction through the gap between Kelley's butte and Sawtooth along the site of the government-trail to Fort Apache and on across the Nantan plateau through the great gap which is now filled with the Seven-Mile Hill Quaternary and Tertiary deposits to join, possibly, the upper Gila. But seismic disturbances came. The whole region was faulted and blocked and the blocks tilted so that the whole plateau area dips north in opposition to the drainage. For a long time the streams cut down their channels as fast as the dip was changed, but finally more violent disturbances occurred: The Nantan plateau and the mountains joining it on the east were so elevated as to dam the outlet of the Cibicu creek completely, thus damming all the drainage of White mountains and the eastern part of the Mogollon range on their southwestern side. At the same time or in earlier times the Apache mountains and Canyon creek fault occurred, which dipped all the strata at a great angle to the east in that region. The plateau part of the area was then completely laked, though it is not at all probable that a great body of water occupied the region; the conditions do not indicate such a condition, but that the deposits were laid down as subaerial fluvial-fans. In this laked area was deposited by subaerial action the Quaternary and Tertiary gravels, sands and clays under consideration.

The deposition of the Salt river, Hinton, and Globe formations is also due to a laking stage, brought about by the faulting which produced the Apache and Pinal mountains and the Sierra Ancha. Salt river now runs through a gap which it has incised in the Archæan-Tonto barrier.

Where did the Quaternary-Tertiary debris come from?—An examination of the Seven-Mile Hill Quaternary and Ter-

tiary showed that a great part of it came from the White Mountain district, because in it are many boulders of the trachyte type which could not have come from any other location within hundreds of miles of the place. It is true that there are other trachyte lavas nearly as close to Seven-Mile Hill canyon as that in the White mountains, but they are at a lower level than these deposits, and of course could not contribute to their make-up. Again the depositing dip of the clays and sands and the increasing coarseness of the debris as the mountains are approached aid in verifying the theory that the material came from the mountains to the east.

The Quaternary on the Cibicu divide indicates by its composition that it came from the west and northwest; it is composed of quartzyte, gneiss and vitreous Tonto sandstone boulders, which, without doubt, came from the worn off edges of the Canyon Creek escarpment, from which at least 3000 feet of rock in vertical section has been removed.

The Hinton and Salt river deposits were laid down by the streams which now flow through them—Cherry creek, Salt river, and Canyon creek. The sediments are debris gathered from surrounding mesas. They are mostly ground up Archæan and Palæozoic rocks, taken from the upper and middle valleys of Cherry and Canyon creeks. The biotite granite particles are easily traced to the middle Canyon creek and upper Oak creek region.

The sediments of Chiddessky, Ellison flat, middle Cherry creek and Globe formations are the result of the denudation of the hills, mesas and mountains in the immediate vicinity of each.

In concluding the discussion of the Quaternary and Tertiary the writer wishes to state that it is probable that some of the debris came from the mountains to the north, from the mountains beyond the Colorado Chiquito.

The Post-Glacial—After the deposition of the sediments just considered, lava flow periods and periods of denudation alternated with each other three times in succession, then a period of deposition set in in which sediments were laid down in the inner valleys to a thickness of several hundred feet in some places. These deposits are the valley farm lands of today.

Besides the inner valley deposits, several bench deposits were laid down. One of which covers a large area northwest of Fort Apache in a bay-shaped flat surrounded by mesas and mountains and volcanic buttes. The sediments of this patch present some striking peculiarities. They are deposited upon a lava sheet which flowed down the valley from the north, dammed up the outlet of the river south of Kelley's butte, and then formed a great lava lake. This area, when the lava was cooled, was still laked by the lava in the river channel and in the lake this Post-glacial material was deposited. Another peculiarity is that three cobble-stone ridges run paralled to each other in a north and south direction the full width of the deposits. They resemble lateral moraines in appearance but on examination no striæ markings were found upon any of the rocks, so we must look for some other explanation than glacial to account for their occurrence. If the channel of White river was blocked at the time of the deposition, as there is every evidence to believe that it was, outside of absolute proof, the streams entering the laked region from the north would have force enough, even with the fall that the streams of the region have today, to carry or roll the cobble stones far out into the lake and, if it was shallow, to roll them to the opposite shore. In this way the ridges were probably produced. They might have been produced in the same manner even if there was no laked area, provided there was not flow enough to extend beyond the flat surface area to cut a channel.

In the Post-glacial might also be placed the travertine deposits of the region. They represent the action of extinct springs; springs which were most active in the interval between the last lava flow and the Post-glacial deposition just mentioned. The largest of these spring-deposits is that of Elsesa on the west side of North Fork about six miles above the White River post-office; and the next in size is on little Cibicu creek, about seven miles northwest of the Indian farmer's residence on the Cibicu. The deposits of each are linear in shape. The latter covers an area of forty acres and the former eight hundred. The little Cibicu deposit is without any spring in its immediate vicinity, though the Grasshopper springs are some three miles farther up the creek. The Elsesa has but one spring connected with it now and it is not a tavertine depositing

spring. Each of the deposits reaches a great thickness, the Elsesa being 250 feet in thickness. The springs were cold as is indicated by the gastropod shells incased in the travertine. The finding of these shells also seems to indicate that the waters of the springs were more or less laked. Besides the shells, beetles and other insects were found. In these deposits are to be found trees as large as the pines of today.

RESUMÉ.

The Archæan strata had been deposited, plicated, raised above the water, and eroded, before the age of the Algonkian. In that age a coast-line slowly encroached upon the Archæan area, paring its ridges, filling its hollows, first, with the coarse siliceous detritus of the advancing beach; secondly, with the finer mud spread by the currents and waves in the shoal-waters that progressively followed the beach; and, thirdly, with the limestone that was slowly formed in the waters remote from the shore line. Associated with this advance of the beach-line and the deposition of sediments were great volcanic disturbances, the lava flows of which are interstratified with the clastics. Most of the lavas then out-poured are of the dioryte, and diabase types. When the shore-line had advanced till it nearly or quite covered the Archæan area, the sea was again removed and the erosive agencies set about to reduce the land area to a peneplain. Where the shore-line was then we cannot tell, neither do we know whether the land area was a small island or a continent. This we do know, however, that the time between the retreat of the sea and its return was of long duration. At last it returned and in it was deposited the Tonto formation followed by the upper Silurian (?), Devonian, and Lower Red Wall group. Then the sea became shallow and the shore advanced back and forth across the region time after time, thus causing it to be swamp or sea according as the ocean receded or advanced. In the swampy periods the *Lepidodendrons* and the *Calamariae* flourished, and in the sea periods the *Productus cora, Productus semireticulatus, Productus costatus, Spirifer cameratus* and *Athyris subtilita* lived. This was the middle Coal Measure period. Before its close the sea gained complete possession again. This middle coal series or upper Red Wall group, was followed by the Aubery group. Then there was

a period of little or no deposition till Cretaceous time. The Laramie was then deposited after which the sea retreated forever from the region. As soon as the sea was expelled erosion began and as the country was being rapidly elevated great rivers chiselled out deep canyons in the strata. This period of incision was of long duration for in many places at least 3000 feet of strata were removed. It continued from the Laramie epoch till the seismic disturbances of Tertiary time blocked the water courses and formed lake basins on a grand scale. Then a period of deposition began which was continuous till near the close of the Quaternary when a period of denudation again set in, which has continued almost without break to the present time.

GEOGRAPHY AND PHYSIOGRAPHY.

Mountains.

The Ellison Dome.—After the deposition of the Palæozoic strata the region in the vicinity of Ellison became land and so far as the evidence goes no more sediments were deposited in the region till in the Tertiary and Quaternary periods. At the beginning of the interval of non-deposition the area was domed. During the period of elevation base-leveling processes began and continued till they removed nearly all the clastics from the Archæan centre, removing from 4000 to 6000 feet in vertical section. On the domed area the streams flowed in all directions towards its rim, as the dry canyons of Tonto, Chevelon, Carrixo, Dry Fork, and Cibiçu indicate. Although the upland surface was reduced to a fairly even plain there still remain remnants of an old upland overlooking the general level of the domed area; in other words, the topography suggests the development of a peneplain which was subjected to further movements before the base-leveling was complete. Then followed additional doming, accompanied by faulting in such a manner as to increase the rock dips both on the east and on the west slopes of the original dome. The west series forms the Sierra Ancha, the eastern the Canyon Creek escarpment which is continuous with the Plateau escarpment south of Salt river. The south part of the dome was also faulted off. Since faulting streams have incised channels along the fault lines in the domed area, and besides removing much of the remaining sediments, they have given off side branches one of which (Salt river)

has captured all the eastern drainage and become the master stream.

The Sierra Ancha.—The Sierra Ancha extends from Salt river in a northwestern direction some twenty or thirty miles, as a massive, faulted block, with its steepest slope on the northeast. This block is composed of Tonto sandstone at the crest, beneath which are Algonkian and Archæan rocks.

The Mogollon Range or Mesa.—This mesa extends from the vicinity of Fort Apache in a northwestern direction, and is of an average width of ten to fifteen miles, and an altitude ranging from 6000 to 7500 feet. The Carboniferous strata predominate, but the eastern and southern extensions are covered by basaltic eruptions. This mesa contains the greater part of the pine and fir timber belt of Arizona. It is also a grazing region. Mr. Oscar Loew visited this region in 1873 and in his report he notes the following facts:

"This timber-covered plateau extends from the vicinity of Camp Apache in a northwesterly direction to the vicinity of the southern extension of the San Francisco mountains, and is of an average width of ten to fifteen miles and an altitude of 7000 feet. It was the source of former grand rivers as is testified by canyons of gigantic dimensions. The canyon of Big Dry fork, for instance, is over seventy miles in length and from two hundred to four hundred feet in depth; the walls are principally sandstone, with here and there limestone, and descend in terraces; sometimes, however, are quite vertical. Around the small ponds or little rills on the bottom of this remarkable canyon an extraordinary vegetable life has been developed. Nothing of the canyon is noticed until one stands on the very margin, where a pathway to the other side is looked for in vain. It was a tributary of the Colorado Chiquito. Its head at the present time is formed by a small creek that sinks when it reaches the juniper region. Numerous creeks head in this plateau. Among them are Chevelon's fork, Cedar creek, and Carrixo creek. The Tonton basin, a deep depression, borders this plateau on the south side. The Carboniferous strata predominate, but the southern [and eastern] extension is covered with basaltic eruptions. Here are many forests, meadows and fine valleys suitable for farming and stock raising."[5]

This mountain is the result of a faulting and tilting on a grand scale. The faulting took place along the line of the Kelley-Salt river dike. The dip of the block north of the fault is constant and in a northern direction; but the dip of the blocks on the south is variable, some dipping towards the dike, others from it. And today East fork of White river, White

by Tonto sandstone which dips into the range at an angle of probably 10 degrees. But on the northeast flanks is a long area of highly metamorphic rocks, covered in most places with lava. In this area stands Chromo (commonly called "Hay Stack") butte, a large volcanic neck that towers hundreds of feet above the lavas of the surrounding area.

Mr. Marvine's description of these mountains is as follows:

"In ascending the Apache mountains, we passed directly from detritus composed of Tonto sandstone, without seeing granite, on to a portion of the [Tonto] bed itself, which here forms the summits of the range, its whole thickness, with some overlying shales in places still remaining. A spur to the southeast of the line of section, but lying much below the summit, also appeared capped with the sandstone. The general dip was northeast, and the mass generally lay below the edge of the mesa [Plateau], of which it was once a continuation, the displacement probably being due to a fault in the valley, the downthrow being on the southern side.

The southeastern end of the range appears to have less of the sandstone upon it, probably being composed of underlying rocks.

Crossing the divide, there are found upon the southwestern slope of the Apache mountains two or three lines of hills composed of the Tonto sandstone, each preserving a gentle northeastern dip and resting on granite, but faulted downward with respect to the summit mass. This system of faults seems to continue to the southwestern side of the Sierra Ancha, where several hills with precipitous southern sides, like others near the "wheat fields" of Pinal creek, are visible."[3]

The Pinal Mountains.—Just west of Globe are the Pinal mountains. They run in a northwest and southeast direction in about the longitude of 111° to 111° 10', and continue from a point somewhat south of Globe to Salt river. Like the Apache mountains, they too were faulted portions of the Plateau, as is attested by the attitude of the Tonto sandstone. Their main mass is of granite, flanked by highly metamorphic crystalline schists. But in the vicinity of Globe and to the south and southwest, the mountains are both flanked and occasionally capped with a pink rhyolyte which breaks down in rugged palisades. Mr. Marvine reported on these mountains as follows:

"Where crossed, the main mass was of granite, but upon their northeast flanks is a long series of highly metamorphic rocks, consisting mostly of crystalline schists, micaceous, chloritic, and talcose, their erosion forming an intricate maze of small valleys, separated by sharp ridges, which present a strong contrast with the more massive features of the mountains. An adjacent spur of the Pinal mountains seems still capped with Tonto sandstone, which dips into the range at

an angle of about 10°, the last recognized southwestern remnant of the Plateau beds. The northeastern flanks of the valley, where exposed, consisted of red granite and allied rocks.

In crossing the range the granite axis was found to extend continuously to camp Pinal and semed to form nearly all its northern and lower parts. To the southeast, however, the topography changes, the range rising in long, even slopes ot three flatly conical masive mountains which form its highest points, and have the contour of rhyolyte, of which they are probably composed. At camp Pinal a light pink rhyolyte lava is encountered bordering the range, and apparently derived from the higher points to the left, though now separated from them by the canyon of Mineral creek. This bordering rhyolyte stands nearly as high as the main ridge where crossed, and, though having a rather undulating surface, its sides break down in most rugged palisades, whose precipitous faces overhang the canyons and rim the borders of the range with almost impassable cliffs. These form an abrupt termination to that mountainous country bordering the plateau region through which we had passed, and extending a long distance either way, look off at once upon the mountain studded deserts of the great Gila valley."[9]

Buttes.

The buttes of the region are of two kinds: Volcanic necks and buttes, of the Monadnock type according to professor Davis' definition of monadnocks.

Buttes of the monadnock type.—These buttes are all included within the "rim" of the Ellison dome and are bits of relief, usually composed of Tonto sandstone, which have withstood the processes of baselevelling. Among them are: Chiddesche, Twin buttes, John Dazen, Sombrero butte, Juniper butte (Devonian) and Catholic buttes (Archæan schists and lavas). The volcanic necks are considered under *volcanoes.*

Drainage.

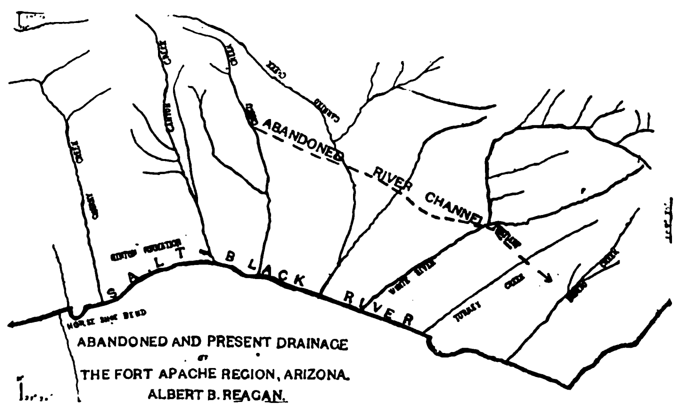
The drainage of the Fort Apache region affords an excellent illustration of a partially diverted and inverted system, effected by complicated faulting and tilting.

The master stream is Salt-Black river. Its location is determined at least within the Apache area by a fault-scarp, extending in an east and west direction. The lower portions of the tributaries on the north have also been determined in their positions by a series of north and south faults. The heads of the tributaries do not appear to have been disturbed in consequence of the tilting. In other words, in this portion of the area the streams are in fact antecedent. The lower courses

of the tributaries have been changed both in position and in direction, and have further undergone various geographical accidents since their original diversion by faulting.

On the basis of stratigraphical evidence the entire system of faults seems to have occurred at the close of the Cretaceous.

Course of the Streams Previous to Faulting.—In the later Cretaceous time the head-waters of the streams now known as Cibicu, Carrixo and White rivers occupied the same position they do now but the master stream was not the Black river of today, but a stream that occupied a position many miles to the north, a stream that flowed east-southeast and not west, as does the present master stream. It was an extension of upper Cibicu. It crossed the divide between Cibicu and Carrixo creeks about due east of the farmer's residence, from which



ABANDONED AND PRESENT DRAINAGE OF THE FORT APACHE REGION, ARIZONA.
ALBERT B. REAGAN.

place it extended along the line of the government trail between the buttes of Sanchez and Sugar loaf, between the buttes of Saw-tooth and Kelley to the vicinity of Fort Apache. From there it flowed southeast probably to join the upper Gila. That that stream occupied the location mentioned for a long interval of time is attested by the deep, wide canyon it occupied. Its canyon southeast of Fort Apache, now completely filled, was twelve miles in width and more than eight hundred feet deep in its central part.

Cherry and Canyon creeks then as now flowed south from the Ellison dome, but instead of being tributaries of Salt river they seem to have held a southerly course across the region of the Apache mountains. Salt-Black river did not exist till after the faulting of the region.

Diverting of Drainage by faulting, and consequent laking.—Before the deposition of the Tertiary the region was much faulted and tilted so that it was laked. At first only two small lakes were formed: one in the canyon of the then master stream southeast of Fort Apache, the other between the Pinal-Sierra Ancha mountains and the Plateau-Canyon creek escarpment, in the area through which Salt river now runs. As soon as the faulting began the head-streams began to adjust themselves to the new conditions, each cutting out a channel in its lower course along a north and south fault to the main east and west fault line now occupied by Black-Salt river. At first the waters of some of the streams flowed east along this fault to the eastern lake, the waters of the other streams west to the western lake. Finally, as the region became more elevated on the east the eastern lake drained west along the major fault into the western lake which in turn drained south between the Apache and Pinal mountains into the Gila river *via* Pinal Creek canyon. After the drainage had continued in this direction for a considerable time a further elevation of the Plateau-Canyon creek escarpment blocked the drainage to the west and made a lake of the entire Black-Salt river basin east of that escarpment, the western lake remaining practically unchanged and still having its outlet *via* Pinal Creek canyon to the Gila.

The sedimentation due to the laking of the region has already been discussed under Tertiary and Quaternary deposits in the remarks on the Stratigraphy of the region, and need not be further mentioned here.

Destruction of Lakes and the present Salt river Drainage.—Near the close of the Quaternary, Salt river re-cut its channel through the elevated plateau-escarpment emptying into the western or Hinton lake. At about this time a channel was cut through between the Sierra Ancha and Pinal mountains, giving Salt river the channel it occupies today in that part of the region. Since cutting the outlet, Salt river and its tributaries in their lower courses have incised themselves to the depth of about 2000 feet.

As the process of degrading went on several geographical accidents happened to several of the streams. White river and its North Fork, for example, cut a deep channel, where they now run in the Cretaceous and were subsequently laked and

completely filled with sediments in the late Tertiary and Quaternary. Then followed the development of a lava plain of considerable extent, covering in fact the greater part of the area discussed in this paper. In spite of this volcanic interruption White river renewed its activity and cut its way though the flow and underlying rocks to a depth of nearly 2000 feet, only to be arrested again by a second eruption. Again, White river renewed its task and proceeded to incise itself in the second flow, cutting completely through the second filling to its former level. After the development of the valleys in the second lava sheet White river was interrupted in its course by local ejections from near Green's point. These flows, however, were confined to the valley floors, extending down stream a distance of thirty miles.

The present position of this stream with reference to the last flow is in part along the contact between it and the preexisting slope or within the limits of the lava sheet itself. In places it has already succeeded in cutting through the entire thickness, while in others it has not yet accomplished that task.

This case serves as an excellent illustration of laking in consequence of faulting, and subsequent development of drainage which is in part inverted and in part diverted.

Springs.

The springs of the region may be divided into the following groups: the extinct springs, the common springs, the hot springs, and the salt springs.

The Extinct Springs.—These springs are now represented by the Elsesa and Little Cibicu travertine deposits. As they have been described under the "Post Glacial," they need not be further mentioned here.

The Common Springs.—All the streams of the region head in springs and are fed by springs gushing from the canyon walls in their channels. Were it not for these springs the water courses would be dry most of the year. Besides those in the canyons, others occur on the mesas and in the mountain districts, and although they are small and not numerous they are quite an aid to stockmen in furnishing water for the stock of the country.

It has been noticed for several years that the springs south of the Mogollon range are gradually drying up; and it is pre-

dicted that, in the course of time, possibly a few centuries, they will become extinct. Their dessication seems to have been going on for a long period of time, probably ever since the close of Pleistocene time.

The Elsesa and Middle Little Cibicu springs, though once very active, as is indicated by the travertine deposits, have long been extinct. The Grasshopper springs at the head of the Little Cibicu are now reduced to mud springs, though they once furnished water enough not only to supply a large village with water, but to irrigate large tracts of land as is attested by the ancient irrigating ditches extending down the Little Cibicu valley from them. The springs at the head waters of Upper Cibicu and Carrixo creeks have now reached the seeping stage.

The water which supplies these springs evidently comes from the plateau of the Mogollon range and the country farther north. In this region practically all the streams which flow toward the north sink into the sand before reaching the Little Colorado, Chevelon's fork being a good example; and much of the water of the Little Colorado itself settles below the surface, reappearing again as springs on the south side of the Mogollon mesa.

Irrigation in the Little Colorado valley is evidently the cause of the drying up of the springs south of the range. When all the drainage of that river basin is used for irrigating purposes, the springs south of the Mogollon will become extinct.

The Hot Springs.—The only Hot springs of the region enter Carrixo Creek canyon through a fissure in the vicinity of the Kelley dike. The heating of the water is, without doubt, due to its coming in contact with heated rocks in the yet uncooled interior along the dike, the springs being a continuation of volcanic activity in the secondary stage. The springs are not numerous, there being about fifteen in all. Their warm and hot waters possess medicinal properties, but on account of their being on the Apache Indian lands they are not used.

The Salt Springs.—These springs are situated at the point where Black river emerges from the Plateau region. They enter the canyon through the Algonkian shales and at the base of the Tonto system of rocks, the salty waters dripping from the canyon walls, the salt crystalizing in stalactite forms or in beautiful figures on the rock walls. In the seventies when the

town of McMillen was in a flourishing condition, there was a move on foot to utilize the salt of these springs: dams, ditches and evaporating pans were put in, but with the decline of that mining town the salt industry was dropped.

Intrusive Rocks.

The intrusive rocks of the region are: Dikes, Laccoliths, and Volcanic Necks. The last named group will be considered when the subject of volcanoes is taken up.

Dikes.

The Plateau-Canyon Creek Dike.—This dike extends from the headwaters of Oak creek south to the summit of the Apache mountains just west of the Plateau escarpment. It is from one hundred feet to a quarter of a mile in width. Its north end is composed of hornblende-biotite granite and dioryte, its middle and southern portion of dioryte and rhyolyte. At least two eruptive periods, remote from each other, are represented here: the first occurred in the Algonkian age, the second after the close of the Carboniferous, possibly as late as the Pliocene period. The lavas of the two periods stand side by side in most places, though there are localities in which the rhyolyte has removed the dioryte completely from the fissure. This dike, therefore, gives evidence that the trachyte (rhyolyte) was erupted last, that each eruption was a fissure eruption, and that the volcanic disturbances were separated by long periods of quietude.

The Salt River dike.—This dike crosses from the north side of Salt river to the south side at the salt springs, from which place it trends west parallel with the river. It is mineral bearing, the mineral being a low grade zinc ore. For many miles the dike dips south-southeast, but after passing the horse-shoe bend of Salt river it becomes vertical in position and farther on takes a northwest dip.

Along the exposures of this dike at many points west of the bend, occur many large volcanic necks or plugs. How far these extend beyond the territory examined was not determined, but enough is known concerning them to warrant the belief that they form a prominent feature in the topography of the country to the west.

Dikes and Veins in the vicinity of Globe.—Around Globe a great many dikes and veins penetrate the country rock, at some points presenting a mesh-like arrangement, while in others they show a radiating position.

The veins are usually mineral bearing. On these are located the Old Dominion, the McMillen, and the other mines of the region.

The Ellison Dike.—Just east of Ellison and west of the west line of the White mountain Apache Indian reservation is a north and south porphyritic dike averaging one-fourth of a mile in width where it emerges from beneath the Tonto near Juniper butte. The porphyry is copper stained throughout and on it are located the Ellison copper prospects. Its extent is not known to the writer farther than that it extends several miles south of the Government trail. It seems to be an uncovered dike of Algonkian age.

The Kelley dike.—The Salt river dike is continued in the vicinity of Fort Apache in the Kelley dike. This division, which is only occasionally exposed, is composed of basalt. On it are situated a line of a dozen or more craters and volcanic necks. From this dike a branch is given off which extends in a northeast direction through the Sugar Loaf and Sanchez butte, and Green Point regions to the east, Mogollon range and the White mountains. On this dike and its northeast branch were situated some of the most active volcanoes or the Quaternary Period.

The White Mountain dikes.—Only a reconnoissance was made of the White mountains, but enough evidence was obtained to demonstrate that a volcanic dike (or dikes) extends in a north and south direction through the entire mountain district and on north and northwest toward the San Francisco mountains. At one time this dike was the vent of a trachyte (rhyolyte) fissure eruption and on it at a later time were located the north and south line of the basaltic craters which now dot the region. This dike seems to be the vent from which the greater part of the lavas now covering the region, and described in this paper, were ejected.

Other Dikes.—There are many other dikes and veins in the region, among which are the *Gneissic dikes* in the Archæan granite near the confluence of Canyon creek and Salt river and the Cherry creek and East Tonto basin.

Laccoliths.

About six miles west and a little north of Fort Apache in the vicinity of the Kelley Butte region is a great mass of volcanic rock, covering a half township, that has every indication of having been intrusive and laccolitic. It is, in structure, exactly like the volcanic rock in the body-wall of Kelley's butte. Moreover, the Carboniferous strata were domed by it originally, as is attested by the tilted strata of that age now flanking it and overlying it on all sides.

Since the volcanic epoch closed to which this laccolith belongs, the agents of denudation have removed the overlying strata so that today its top and east flank are exposed.

Extrusive Rocks, Volcanoes.

Besides the numerous extinct volcanoes that are found along the dike-lines already mentioned, there are many cinder cones scattered here and there over the region, especially in the Nantan Plateau area. Most of these volcanoes are of the sanidin-doleryte type, the trachyte-rhyolyte craters, with few exceptions, being removed by erosion and covered over with Tertiary and Quaternary debris or with the lavas of later eruptions. Some of these volcanoes are of the butte type and demand further mention. The remaining types will not be considered further.

Volcanic Buttes.

Among the volcanic buttes of the region are: Kelly, Sugar Loaf, Sanchez and Saw Tooth northwest of Fort Apache, and Chromo seventy miles southwest of Fort Apache. The former group are of the sanidin-doleryte type and penetrate Carboniferous strata, the latter is composed of trachyte (rhyolyte) and penetrates only Arcræan schists at the surface. Both these groups protrude through the surrounding strata which are usually much broken and displaced. These buttes not only serve as an index of the amount of base-leveling that the country has undergone since they were active, but, on account of the lavas and Quaternary and Tertiary sediments being removed from around them, they give opportunity to study the effect of intruded material upon the surrounding strata. Sugar Loaf, for example, not only reduced the surrounding sandstone to quartzytes and the lime rocks to marbles in its immediate vicinity; but the hot gases escaping from fissure vents at a con-

siderable distance from the crater affected the surrounding strata in a similar way.

As to how these buttes were formed since they are possessed of neither the form nor the structure of a surface eruption, the writer conceives them to be vestiges of flues though which an eruption reached the surface at the time of the flooding of the region with lava. The last contents of the flues, congealing within them, formed pillars of trap that opposed a stubborn resistance to the atmospheric agents which have destroyed the surrounding strata. They are casts, in lava, of which the mould was the conduit of a volcano, now not only extinct, but destroyed by erosion. In short, they are volcanic necks.

Lava Flows.

The erupted rocks are: Diorytes (and Diabases); Trachytes and Rhyolytes; Basalts, (including the Sanidin-doleryte lavas). These were erupted in the order given.

Diorytes (and Diabases).—In the Canyon creek region the great dike and the lavas interstratified with the Algonkian series are dark to dark olive green in color, rarely form cliffs, and on weathering crumble into a rather light olive green, coarse to fine sand. This lava was also noticed at several places in the Tonto and Cherry creek basins. They are undoubtedly of Algonkian age.

Trachytes and Rhyolytes.—The whole region, with a few exceptional patches, seems to have been covered with lavas of one or the other of these classes or with both. As has already been stated, Sierra Blanco is made up of trachyte, veneered with a sheet of sanidin-doleryte. From these mountains the two sheets extend over the entire eastern part of the region here described, reaching to the southwest more than forty miles to the Nantan escarpment, along which the lava series, according to G. K. Gilbert,[10] consists of:

			feet
"1.	Typical sanidin doleryte; in beds 20 to 50 feet thick and remarkably continuous		1000
2.	Silicic trachyte, (rhyolyte:) feet		
	a. Pale pink to white, lithoid, light, somewhat brecciated	110	460
	c. Purple, hard, fine grained, brecciated; base not seen	320	
	b. Dark brown, brecciated and amygdaloidal	30	
	Total		1,460"

But west of the Plateau break in the Apache and Pinal mountains the acidic lavas become a rhyolyte varying in color from white to a dark gray in the former, to a pink in the latter. For convenience the lavas of the two districts will be considered separately.

Rhyolyte in the Apache Mountains.—From Sombrero butte south across the Apache mountains to Globe, and in fact the entire area included between Pinal creek and the Plateau region, is covered with rhyolyte where it has not been removed by erosion or covered with sediments. At least two flows have occurred in this district separated from each other by a long lapse of time. The last flow was a whitish colored rhyolyte and is found on Cherry creek interstratified with the Tertiary deposits of the Hinton formation. This flow either did not cover a large area or its extension has been almost wholly removed. The rhyolyte of the first flow is a massive, fine grained, heavy, dark gray to blue and light colored rock, weathering to a seal brown, and breaking down in palisade cliffs. It is the lavas of this flow that are the most extensive of the rhyolytes in this region and that once covered the enire area with the lava sheet 2500 feet in thickness, provided the lava sheet extended to the level of the top of Chromo butte, as there are reasons to believe it did. (See discussion on Volcanic Buttes), 1500 feet of which still remains on the northeast flank of the Apache mountains.

That the date of the lava flows was subsequent to the faulting is shown by the fact that they extend to the very edge of the Plateau escarpment but do not cross over it. Furthermore, their ejection occurred a long time before the deposition of the Hinton Tertiary formation, so long before that erosion had removed most of the lava from the region.

The age of these lavas seems to be Tertiary and pre-Pliocene.

With reference to the vents from which the lavas were emitted, it is the opinion of the writer that the rhyolytes represent fissure eruptions and were associated with the Plateau-Canyon creek dike south of Salt river, and that the craters and buttes which are now in the region were only active in the last eruptions, the lavas then ejected being wholly removed, except where interstratified with the Tertiary.

The Rhyolyte of the Pinal mountains.—This rhyolyte borders the mountain range on both the east and west sides, but does not cap the summits, except in the region south of Globe. It may be recognized and separated from the rhyolyte of the Apache mountains by its color, the former being distinguished by its gray color, the latter by its pinkish hue.

Mr. Marvine, in his report on the trip "From Camp Apache to the Gila Valley" makes the following statements concerning this rhyolyte:

> "To the southeast" [of Camp Pinal] "the topography changes, the range rising in long even slopes to three flatly conical, massive mountains, which form its highest points, and have the contour of rhyolyte, of which they are probably composed. At Camp Pinal a light pink rhyolitic lava is encountered bordering the range, and apparently derived from the higher points to the left" [to the south], "though now separated from them, I understand, by Mineral creek. This bordering rhyolyte stands nearly as high as the main granite ridge where crossed, and, though having a rather undulating surface, its sides break down in most rugged palisades, whose precipitous faces overhang the canyons and rim the borders of the range with almost impassable cliffs."[4]

These lavas underlie the Quaternary at all points and were much eroded before the Quaternary was deposited. They therefore date back to the Tertiary and are most likely Pre-Pliocene.

Other Patches of Rhyolyte.—A rhyolyte not unlike that in the Apache Mountain district was encountered in Pleasant valley on Cherry creek. The Catholic buttes west of Ellison are built up of this lava and from these buttes it extends north and west across the above valley to the Tonto basin, but in the valley proper it is covered with the Tertiary and Quaternary sediments. The age of this lava undoubtedly antedates the Pliocene for the reason that these deposits are superimposed.

The Basaltic Lavas, including the Sanidin-Doleryte Type.—Lavas of the true basaltic type are the last lavas erupted in the region. They are found only in the Sierra Blanco country, but lavas of the sanidin-doleryte type preceded them and flowed over the entire part of the plateau region visited, from the White mountains to the Canyon creek fault, the greater part of which still covers the country, capping continuous or detached mesas. There were at least three flows of this type of lava separated from each other by long periods of erosion. A dark, compact to fine grained basalt, not unlike that described by Marvine along the Mongollon mesa near the San

Francisco mountains, was encountered at several places in the Pleasant valley district on Cherry creek. After the rhyolytes and trachytes of the region were ejected, the country suffered denudation for a time, followed by deposition to an extent that when the first sanidin-doleryte lava flow occurred its lavas flowed over an aggraded plain. Another period of erosion then commenced and continued till the rivers of the region had cut their channels to their present level. At this time a second lava flow occurred, followed by another period of erosion which lasted till the rivers had removed the lavas from their channels. Then the volcanoes in the vicinity of Green's point ejected a stream of lava into the North Fork of White river which flowed down the stream nearly to Salt river, as has been stated on a previous page.

The lavas from these flows were ejected from the dikes and volcanoes in the White Mountain region, and from the volcanoes in the vicinity of Green's point, and along the Kelley dikes and in the Nantan plateau. These lavas in habit and color are identical with those of the basaltic family. They spread in broad, sometimes thin sheets, are vesicular, the cavities being usually large and the partitions which separate them thick. In typical specimens the matrix is dark iron gray, and the imbedded feldspars are sanidin, sometimes a half inch in diameter. These lavas are further distinguished by graduation, through a change of matrix, into a true trachyte (Gilbert). Moreover, these lavas were found to inclose limestone particles in the amygdaloid spaces which undoubtedly were taken up during the act of protrusion. To use the words of Mr. Loew:

"No chemist will admit that the lime was contained in basalt before its ejection since it would have been combined with the silicic acid of the molten mass and the carbonic acid liberated. Neither is there any foundation for the hypothesis that this carbonate of lime was deposited by infiltration; to a close observer this appears quite an impossibility. At places where observed, (Sierra del Gila, Rio San Carlos, Camp Apache) its presence could be traced without any difficulty to the strata of limestone that had to be burst by the protruding volcanic material. The limestone broken into fragments by the concussion and heat of the molten mass fell in small particles upon and became entagled by it. The heat, however, liberated part of the carbonic acid of these limestone particles, and formed a bubble that could not escape, the mass assuming a thicker consistency after its ejection. The pressure prevented the

total decomposition of the limestone particles, but the heat impartd to them a crystalline structure; hence the 'calcite' in the amygdaloid spaces."

The age of these lavas is undoubtedly late Quaternary because they overlie the Quaternary of the Plateau and underlie the Post-glacial.

Economics. Climate.

The tablelands and mountains of this region are cool in summer but the climate is not severe in winter. The valleys and lowlands are very hot, frost being seldom seen in the Salt river and Globe districts. The country as a whole is arid, the precipitation at Fort Apache in 1900 being but twenty inches, and crops are raised only by irrigation.

Soil.

The soil is not deep but is fairly fertile even on the table lands. In the valleys, where irrigated, crops do well, and on the table lands are filaree and grama grasses and forests.

An analysis by Mr. Loew of the soil on the Mogollon range resulted as follows:

Physical condition: Color, dark; consistency, loose.

	Per cent.
Sand	42.20
Silt and clay	37.98
Hydroscopic moisture	10.98
Humus and chemically-bound water	8.84
Chemical Constituentss	
Potassa	0.115
Soda, Lithia	Traces
Magnesia	.029
Lime	0.153
Phosphoric acid	0.058
Oxide of iron, Alumina, Sulphuric acid — by diff.	2.013
Total soluble in hydrochloric acid, water included	22.188
Insoluble quartz and clay	77.812
	100

Vegetation.

This region may be divided into four distinct plant zones (according to altitude):

1.—This zone includes all the lands of the region above 5800 feet. It is well timbered, the principal trees being pine and fir.

2.—This zone includes all the lands whose altitude is between 4900 and 5800 feet. In it common juniper, Juniper occidentalis (cedar), piñon, and cactus flourish, and grass grows fairly well.

3.—All lower Canyon creek, Cherry creek and Salt river canyons, the foot hills of the Apache mountains, and the region of the Hinton formation included between the altitudes of 3500 and 4900 feet are known as the zone of Cactus, Agam, Obione and Artemisia (Grease-wood and Sage-brush). It is further characterized by the fact that its grass (Filaree and Grama) with few exceptions is poor, the soil on which it grows being derived from granitic or late volcanic rocks.

4.—This is a zone of Cactus (Cereus giganticus predominating), Yucca, and Agave (mescal, most related to Agave decipiens). The altitude of this zone is from 3000 to 3500 feet. It has a scanty vegetation, scarcely any grass at all; but where there is water, a most luxuriant vegetation springs up.

Irrigation.

Though the region described in this paper exceeds 6000 square miles, only 5000 acres (at most) are under cultivation, not because of a lack of water, but because the streams are all inclosed within narrow and deep canyon walls. There are a few places, however, where ditches could be taken out and more land irrigated, but in these places (Forest Dale, and in the Middle Carrixo and Cibicu valleys) the streams from which the water must be taken are dry creeks most of the year. What is really needed is a series of storage reservoirs that will catch the water in flood time and hold it till a time of need. As the lands are mostly on Indian reserves, steps are already being taken by the government to build such dams that the Indians may have more lands to farm and become self-supporting. That storage reservoirs will prove a success is shown by the fact that a prehistoric people built a village two miles west of the Grasshopper springs so that it dammed the outlet to a stream and from the water thus stored they irrigated lands enough below the village (several hundred acres as is indicated by the ditches) to supply food for at least 500 people, not for a short length of time but for a great many years, as their graveyard attests.

Mineral Resources.

Coal.—A coal seam was observed north of Forest-dale in a formation which the writer took to be Laramie; but neither the extent nor the quality of the coal was ascertained.

Building Stone.—That this region has an abundance of building stone goes without saying. The Red Wall sandstone and limestone are all good building materials, besides there are hundreds of square miles of granites, and Tonto sandstones. The last is one of the best classes of building material.

Salt.—The salt of the salt springs and its properties has been mentioned under the subject of "Salt Springs," and need not be further mentioned here.

Gold, Silver and Copper.—The mountains, the Ellison dome, the Tonto basin, and the Salt river and Canyon creek regions are crossed in all directions by mineral bearing veins. Nearly all are copper bearing; some, silver; and some, gold; while some have all three of the above elements in the same rock. The ore, however, is unually of a low grade. The majority of these veins are on Indian lands and of course are inaccessible to the miner and prospector. A bill was introduced in Congress recently to throw the Indian lands open to prospectors, but it failed to become a law.

The best prospects and claims are to be found at the following points: Ellison's copper prospects on the porphyritic ridge (ledge) near the post office of the same name, and his gold prospects in the Tonto basin together with the claims in the vicinity of McMillen, and Globe.

The Ellison Copper Prospects are located on the porphyritic dike just west of the west line of the White Mountain Apache Indian reservation and just south of Juniper butte. The prospects are some twenty-five in number, and all present good indications, though none of the ore is of a high grade. Eastern capitalists have visited the region lately, and fair figures have been offered for the property.

The Ellison Gold Prospects are situated just under the "rim" in the East Tonto basin. The site of the prospects was not visited but ores from them were examined. The least value of ore assayed was $25.00 per ton, though the most of it was much better, some of it assaying $150.00 per ton. The

vein is said to be wide and to date there are seventeen prospects on it. They are owned by Ellison and Company.

Oil.—Prospecting for oil in now going on in the Pinal mountain region. The Pinal Parafine Oil Company have now drilled a well to the depth of 1053 feet. The drill is in gray sandstone, in which the occurrences of shale are frequent. Judging from indications, an abundance of oil will be obtained.

Mining.

Placer.—The Quaternary gravels on the Cibicu divide and in the vicinity of Globe and at many other places in the region are known to contain placer gold, but to date no placer mining is carried on because of a lack of water for hydraulic purposes.

Mines.—For years the Globe district has been one of the leading mining regions of Arizona and such it is today. Among the mines of the region are: McMillen, Christmas Lode, Rescue, Mineral creek, Pinto creek, The Globe-Boston Copper-mine, and the Old Dominion.

McMillen, situated about 15 miles northeast of Globe, is an abandoned mine at the present time, though work will likely be resumed in the near future. The ore is silver and at the surface was paying in quantity but at a depth of 400 feet the ledge, eight feet in width at top, tapered out to a thin edge. The ore is on a contact between volcanic rocks, and the Palaeozoic.

The *Rescue* mine is situated on a contact, as my memory serves me now, between Archaean granite and Palaeozoic rock. The lode is silver-bearing and runs on an average from 100 to 250 ounces per ton, some of the ore running as high as 3,000 ounces, the vein, however, is not large.

The *Big Johnny* mine is situated on a large lode. The ore is a high grade, exceeding 20 per cent. in copper and some of it running high in silver. The company controlling the mine, W. Pohl and H. T. Wendlehorn, sell their ore to the Old Dominion Mining Company.

The *Pinto Creek* mines are on a contact lode between rhyolyte and Archæan granite; the ore is principally gold and is found in paying quantities. The properties are owned by the Arizona Hancock Consolidated Co. Besides shafts

already complete and in working order the company is sinking a 450 foot shaft, which on April 10, 1903, was practically completed.

The *Globe-Boston Copper* mine is owned by a company of the same name. The mine is situated about one mile northeast of Globe on a contact copper stained lode, ranging from eight to twelve feet in width. Besides shafts that are already completed and that have been in working order for several years, the company has just finished a double compartment shaft, which is 465 feet deep.

The *Old Dominion* is the oldest mine in the region, having been in operation more than thirty years. It is situated just at the north end of Globe and at the terminus of the Globe railroad. For many years there was no railroad to the place and the copper had to be freighted in wagons to a place of shipment; but now that a railroad has entered the region freight is reasonable and this mine as well as the others of the region, together with Globe itself, are in a prospering condition.

This mine is situated on a mineral bearing horizon eighteen feet in width, and produces a fair grade of copper ore. On April first (1903) it had 3,800,000 pounds of 70 per cent. matte on the dump, and 7,000 tons of flue dust.

The Old Dominion Company is now sinking a new shaft and making many other improvements amounting to $100,000.00. Besides contracts have just been let for an equipment of seven Stirling boilers of 325 horse power each.

Besides the mining companies already in operation in the district, the Globe Mining Company with a capital stock of two and one-half millions, has just been incorporated for the purpose of operating in the region.

It is not necessary to remark that Globe as a mining district has a bright future before it.

Water Power.

Before reaching Phoenix, the water of Salt river is used up or sinks into the sand, so that no water power of any kind can be developed in the region. Therefore, if water power is to be developed at all on this river, it will be necessary to go to its upper division to develop it. Plans for such an undertaking have been under consideration for some time,

and experts have examined the upper Salt with that end in view. The scheme is to tunnnel through Horse-Shoe bend and by thus shortening the river increase its fall. Moreover, in thus tunnelling through the Archaean mountain that causes the bend in the river, the plan is to narrow-in the tunnel towards its western (lower) terminus and thus concentrate the whole volume of the river at one point to run a powerful electric plant. This plant, it is expected, judging from the volume of water now in the river, will not only have power enough to light the town of Globe, move the tram-cars at the mines and separate many of the ores by the electro-process; but in addition will furnish light and motor power for the cities of Tucson, Prescott and Phoenix.

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1. G. K. Gilbert, U. S. Geogr. Sur. west of the 100th Meridian, Vol. III, pp. 163-4.
2. G. K. Gilbert—Ibid, p. 164.
3. G. K. Gilbert—Ibid, p. 165.
4. A. R. Marvine—Ibid, p. 223.
5. Oscar Loew—Ibid, p. 587.
6. G. K. Gilbert—Ibid, pp. 526-7.
7. G. K. Gilbert—Ibid, p527.
8. A. R. Marvine—Ibid. p. 221.
9. A. R. Marvine—Ibid, pp. 221-3.
10. G. K. Gilbert—ibid, p. 528.
11. Oscar Loew—Ibid, p. 642.

University of Indiana, June 25th, 1903.

PROBABLE PRE-KANSAN AND IOWAN DEPOSITS OF LONG ISLAND, N. Y.*

By M. L. FULLER, United States Geological Survey.

There are on Lonk Island two great gravel formations older than the Wisconsin: (1) the Pensauken, and (2) the Manhasset. The Pensauken consists largely of quartz pebbles, but carries occasional granitic fragments, which, in rare cases, may comprise a third of the pebbles. These pebbles, whether basic or acid, small or large, are alike rotted throughout, and can be readily crushed in the hand. The gravels rest on an eroded

* Published by permission of the Director of the United States Geological Survey.

Cretaceous surface having a probable relief of several hundred feet. During their deposition the land was submerged to the 300 to 360 foot level, to which hight the gravels accumulated with a rather flat upper surface. The deposition is believed to have taken place when an ice sheet existed not far to the north, and furnished considerable amounts of granitic materials. Following the deposition the gravels were uplifted and eroded until only an occasional remnant on the crest or slopes of the Cretaceous uplands remained. Outcrops can, however, be seen at a number of points along the north shore and in the Wheatley, West, and Half Hollow hills, and can be recognized in well borings at many points. This gravel has not previously been recognized on the Island, the yellow gravel of Merrill,[1] Hollick,[2] Crosby,[3] and Woodworth[4] all belonging to the Manhasset or later deposits. It has, however, been recognized at many points by the writer and associates, and can be mapped both at the surface and beneath the later drifts over considerable areas. Special examinations by Mr. G. N. Knapp of the New Jersey Geological Survey in company with the writer, served to establish its probable identity with the Pensauken of northern New Jersey, with which it agrees closely in composition, weathering, altitude, relation to the Cretaceous, and in subsequent erosion. Because of the marked weathering of its materials, which is much greater than that shown even by the Kansan of the Mississippi valley, and because of its deposition during the first recorded advance of the ice, it has been assigned to the Pre-Kansan or to the Kansan glacial stage, probably the former. It would seem from descriptions to correspond with McGee's high level Columbia beds of New Jersey and southward.[5] It is believed to be probably contemporaneous with the Carmichael clays of the Monongahela terraces[6] and with the terrace gravels of the Lower Allegheny river in western Pennsylvania. The exact relation to the old extra-morainic drift of New Jersey and Pennsylvania has not yet been worked out.

The next succeeding gravel definitely recognizable in the surface exposures of the Island is the Manhasset gravel, first described in detail by Woodworth.[7] This is separated from the Pensauken by the immense erosion interval mentioned, during which all but an occasional patch of the latter was removed and by the periods of deposition noted on a subsequent page. The

Manhasset gravel consists of sands and gravels containing abundant slightly weathered granitic material, and was probably deposited during a submergence to the 200 to 240 foot level, at which altitude they form a marked plateau along the north shore west of Port Jefferson. At some points a bowlder bed, composed of what seems to be berg-dropped materials, occurs near the middle of the series. The present work has extended the Manhasset area far to the eastward, the gravels being exposed beneath the Wisconsin moraine to Mattituck, and again beneath the morainal drift on Shelter island and of the south fluke to Napeague bay. South of the moraine they have been found by the writer in strong development in the form of terraces near Bethpage and as a sheet over the Half Hollow hills. They constitute the low Rockaway ridge and Barnum island swells and are shown by well sections to frequently underlie the Wisconsin outwash plains at a depth of a few feet at many points. They overlie all older deposits unconformably. The deposition is believed to have taken place when the ice rested close to the north shore of the island. On the north shore the gravels constitute the major portion of the Pliocene or Pleistocene yellow gravels of Hollick,[8] the Pleistocene yellow gravels of Merrill,[9] and the Manhasset gravels of Woodworth,[10] while on the south shore of the island they are the supposed Tertiary gravels of Crosby[11] and Woodworth.[12] It is probable that they are to be correlated with the Mohegan Bluff beds of Block island,[13] the Tisbury beds of Martha's Vineyard,[14] with a part of the Truro beds of cape Cod,[15] and with certain gravels of the north shore of Nantucket.[16] No representative was detected by the reconnaissance of Mr. Knapp and the writer in New Jersey, but their altitude and relation to the Pensauken suggests that they may be the equivalent of McGee's Lower Columbia deposits of the Atlantic coastal Plain.[17]

The Manhasset stage is separated from the Wisconsin by a long erosion interval, apparently similar to the Peorian interval between the Wisconsin and Iowan in the West. In weathering they agree with the Iowan deposits rather than with the much more strongly weathered drift of the Illinoian stage. Early in the work they were provisionally assigned to the Iowan while the subsequent erosion interval was regarded as the Peorian. Later Mr. A. C. Veatch, who was associated with the

writer in the work, discovered and traced out by means of some thousands of samples from well borings a definite clay bed (salt marsh or submarine deposit) 100 feet or more in thickness which underlies the Manhasset and is in turn underlain by glacial gravels of an invasion intermediate between the Manhasset and Pensauken. The same beds were afterwards recognized in the strongly folded series on the shores of Gardiners island and at a number of points in the western portion of Long Island. The gravel bed, designated as the Jameco, is regarded by Mr. Veatch as Kansan, while the clay has been correlated with the Sankaty of Nantucket and referred to the Yarmouth stage. The folding is regarded as due to the Illinoian ice sheet. These discoveries, which perhaps were the most important geological results of the work, afford the connecting links which complete a glacial series agreeing in number, intervals, sequence, and weathering with the glacial succession established in the Mississippi valley, and corroborates the provisional correlation of the other gravels by the writer.

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[6]M. R. Campbell. U. S. Geol. Surv., Masontown-Uniontown Folio No. 82.

[7]loc. cit. [9]loc. cit. [11]loc. cit.

[8]loc. cit. [10]loc. cit. [12]loc. cit. Map.

[13]Unconformities of Martha's Vineyard and of Block Island. Bull. Geol. Soc. Am., vol. 8, pp. 197-212. Glacial brick clays of Rhode Island and Southeastern Massachusetts: Geology and Geography of the clays. U. S. Geol. Surv., 17th Ann. Rept., 1, 975-988 (table p. 988).

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THE DEVONIAN ERA IN THE OHIO BASIN.*

By EDWARD W. CLAYPOLE.

III. THE VERTEBRATE FAUNA OF WESTERN APPALACHIA.

The Corniferous limestone contains the remains of fishes and these are the earliest traces of vertebrate life yet known in Ohio. They consist of the jaws and body plates of a large ganoid, named by Dr. Newberry, *Onychodus*, and of the cranium of another, the *Macropetalichthys rapheidolabis* of Norwood and Owen, now known in consequence of the loss of the original type, as *M. sullivanti.* These two species, of which the former is more abundant at Delaware and the latter at Sandusky, seem to have been the most numerous fishes of the period as their remains are by far the commonest that are met with in these strata. The bone-bed which caps the Corniferous proper is composed largely of broken fragments of the former species not unmixed with others. Little has yet been done in the working out of the remarkable sheet of fossils, but persistent and careful search will doubtless, in the future be rewarded with valuable results.

In the reports on the geological survey of Ohio there are excellent descriptions from the pen of the late Dr. Newberry of the portions of *Onychodus* thus far identified and very little can be added to his account. Cope has given a few additional details regarding Macropetalichthys in a paper read at the Indianapolis meeting of the American Association, in 1890.· But beyond this, little or nothing has been added to our knowledge during recent years. No part of the fish except the remarkable

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* Continued from page 250.

cranium has been recognized and we are consequently ignorant of the rest of its structure.

Besides the two above named species great chimaeroid fishes, the Rhynchodi with heavy crushing teeth or jaws—immensely magnified representatives of Chimaera—also tenanted the Corniferous and Corniferous-Hamilton seas. Acanthaspis and Acantholepis—lineal descendants of the pteraspids and, perhaps, of Palæaspis, represented that ancient family in the Devonian waters, while the elasmobranchs if not numerous were certainly not small, if we may rely on Machæracanthus as an indication of their armour. Coccosteus, too, still lingered on and probably the future will reveal to us others of greater and less size, the companions of these in Corniferous Ohio, especially from that ichthyic cemetery, the bone-bed.

On a general review of the vertebrate fauna of the Corniferous the palæontologist is disposed to assign to it an age somewhat less than that of the lower Old Red sandstone of England and other parts of Europe, in consequence of the absence of the cephalaspidian forms, which so strongly characterize the lowest Devonian horizon on that continent. With the two exceptions noted above, none of these have yet been reported from the strata of Appalachia. But they are known in the northeast, where the Canadian geologists have found them in the lower Devonian beds at Campbellton. And their presence in the Upper Silurian of Pennsylvania may be regarded as an indication of freer connection between the European and American areas in earlier times than in the Corniferous.

The Corniferous-Hamilton—the equivalent of the eastern Hamilton—supplies many of the above forms and carries the record over the almost total blank exhibited by the former in the east where scarcely any ichthyic fossils have yet been found. A Coccosteus? reported by me from the Hamilton sandstone of Perry county, of Pa.,* and a Dinichthys found by Dr. Lincoln in the Marcellus shale at Geneva, N. Y., constitute almost our whole list of Hamilton fish-fossils from the eastern strata.† Apparently the fishes of the Corniferous were tenants of the open sea and the clear water, where dwelt the coral polyps and where the deposits were limestone. We may almost venture

* AMERICAN GEOLOGIST, March, 1893.

† *Op. cit.*, Nov., 1893.

the supposition that, if a vertebrate fauna is ever found in the lower Devonian of the eastern Appalachian gulf, it will prove to be different from that which is already known in Ohio.*

While the species named above, with others, inhabited the coast, the open sea was possessed by another fauna. Indications are not lacking of the persistence of the vertebrate fauna of the shales as has been demonstrated of the invertebrates. It is far from improbable that the great placoderms of Ohio are the descendants of others that held the muddy eastern shores of the gulf in Corniferous days. *Dinichthys lincolni* proves the existence of that genus in New York in the Marcellus subperiod and is the more significant when we consider the almost total lack of fish fossils from the Hamilton group.

On this view the great placoderms must have migrated westward in the gulf as the condition of the bottom became more favorable and congenial to them (in consequence of the extension of the mechanical deposit poured into the northeastern area through the New York estuary) supplanting the previous occupants of the ground either by displacement or destruction. To the possible objection that no fossils of the kind are reported in the eastern Corniferous, the answer is obvious. No shore deposits of that age are known there. It is not easy to realize what must have been the extension of the Corniferous to the eastward. Its beds have been so completely destroyed that the Corniferous limestone retains its purity in most places quite to its outcrop. But that there was a margin, and that mechanical sediments once existed there, may be assumed as axiomatic and in these sediments were probably buried the ancestors of the vertebrate fauna of the great shales of Ohio.

The degree to which the eastern edges of the palæozoic strata of Appalachia have been destroyed may be in some measure realized upon consideration of the details given elsewhere by the writer,† which show that 153 miles of strata have actually been shortened into 65 miles, thus compressing the surface and reducing its length along the line of section, by 88 miles. Such a reduction (allowing liberally for possible error)

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* Undetermined plates of placoderms exist in the Devonian of Iowa, according to Calvin.

† Pennsylvania before and after the elevation of the Appalachian mountains. *Amer. Nat.*, March, 1885.

must involve the destruction of miles of the eastern shore deposits and their contained fossils as above assumed.*

In the Black shale overlying the Corniferous-Hamilton, i.e. the Huron,—were found the earliest specimens of that remarkable fauna which has rendered the Ohio shale a classic ground. Dinichthys, laid open by Hertzer's fracture of one of the great concretionary masses, which characterize this stratum, at once attracted attention, and though a few other species have come to light, it is not a little singular that nearly all the great number of specimens found should belong to the original species—*D. hertzeri*—evidently the tyrant of the western gulf; though this fact undoubtedly proves that other fishes shared the ground with the monster and supplied him with food. The great mass of this bed, 300 feet thick, is however, yet unexplored, so that it would be rash to assume the scarcity of fossils everywhere. Mr. Hertzer's researches were almost entirely limited to the district around Delaware.

But in the vast wilderness of the Erie shale, overlying the Huron, not the faintest trace of a vertebrate fauna has yet been found in Ohio. Correlating this as the extension chiefly of the eastern Chemung in which a moderate number of fossil fishes have been found, (see table) this absence is a little surprising. It is true that other fossils are very scarce, but the same may be said of the black shales above and below and the lack is therefore scarcely explained. There is no obvious cause to be assigned for the apparent barrenness in fossil fishes of the Erie shale or middle mass of the Ohio great shale, and it is better to expect that they will yet be found than to explain what may after all be merely a difficulty due to our imperfect knowledge.

The Cleveland shale, or the upper black portion of the great shale, was long considered equally barren. But within the past few years it has yielded to the labors of a few earnest collectors one of the richest and most remarkable fossil faunas that are known from any part of the world or from any geological horizon. Messrs. Wheat, Filey, and Terrell, almost as it seemed by accident, became aware that this stratum in the region around the city of Cleveland contained fragments of fishbone

* The marginal portions of these strata were, of course, omitted from my map of the Corniferous sea, as its insertion would be purely theoretical, and the same is true of the maps of the other strata. (Reference is here made to maps published in the AMERICAN GEOLOGIST.)

and from the low cliffs on lake Erie, where the shore at Avon point is constantly cut away by the waves, Mr. Terrell collected those strange forms which the late Dr. Newberry made known to the scientific world. Led at first to a false inference concerning the horizon on account of the similarity of the rock and its fossils to these others he referred the beds to the Huron shale and correlated the fossils with *Dinichthys hertzeri* and its contemporaries. But later research has shown that the strata belong at the top of the great shale and that their *Dinichthys* is not *D. hertzeri;* it has accordingly been named *D. terrelli.* Of this great fish, most of the armour plates of the head and many of those of the body are now known, and considerable progress has been made with its reconstruction.

SECTION OF THE CLEVELAND SHALE IN CUYAHOGA COUNTY.

Cleveland Shale.	10′	Large Cladodus. Dinichthys terrelli. Gorgonichthys. Titanichthys. Titanichthys clarki, T. rectus.
	8′	Small Cladodus.
		Dinichthys intermedius, Titanichthys.
	15′	D. intermedius.
		D. intermedius.
		Coccosteus.
	8′	No fossils at Brooklyn, fossils on Rocky river.
Erie Shale.		No fossils.

Mr. Terrell's researches did not stop here. He rapidly added to the fauna other equally novel forms, Mylostoma, Diplognathus, Glyptaspis and Titanichthys, without mentioning numerous smaller and less striking species. In a few years an-

other collector enteréd the field in the person of Dr. William Clark, of Berea, who became impressed with the thought that similar fossils might exist in his own neighborhood in the black shale of the Rocky river. His results surpassed even those of previous workers. In addition to large numbers of the old forms, a new and equally gigantic Titanichthys and, later, the yet more ponderous Gorgonichthys were added to the fauna of the shale, while the immense mandible of Brontichthys has since completed the quaternion. Nor did the species remain single. Of both Dinichthys and Titanichthys several species are now known varying in size from the huge D. *hertzeri, D. terelli, Titanichthys agassizi* and *T. clarki* to minute forms which afford scarcely a mouthful to their colossal congeners. Trachosteus and Actinophorus lengthened out the list and were followed a little later by a completely new fauna consisting of a magnificent series of selachian fossils, giving us a knowledge of the early forms of this group far surpassing all that was previously known, and rendering the Cleveland shale of northern Ohio the typical ground for elasmobranch history.

For more minute details regarding this remarkable fauna the reader is referred to the tables of the vertebrate fauna of the Appalachian gulf and to the section containing descriptions of the species. The above general account will sufficiently indicate the marvelous revelations of the Cleveland shale and their value in filling a gap in the geological record of ichthyic life and evolution.

IV. THE VERTEBRATE FAUNA OF EASTERN APPALACHIA.

No such discoveries as the splendid series of fossil fish, brought to light, in Ohio, by the unwearied labors of Hertzer, Terrell, Fyler, Wheat, Kepler, Clark and others, can be reported from the east. There few relics of this class have attended persistent search during fifty years, especially in New York. An examination of the tables will fully display this poverty of the eastern fossil fauna in vertebrates.

The Oriskany has yielded no fish remains and the Corniferous, so rich in the west, is almost equally barren in the east. *Machaeracanthus,* with one or two species, represents probably the elasmobranch fauna of that time. A single tooth of Di-

nichthys found by Dr. Lincoln and described by myself* with a few small spines and some shagreen reported by Beecher, are the only known forms from the Marcellus. In the Hamilton proper, an equally striking poverty is observable. A Coccosteus from middle Pennsylvania† and a Ctenacanthus from New York (Wright) are nearly all the vertebrate fossils yet announced.

The Genesee and the Portage continue the same story. A dorsal plate of Dinichthys (Ringueberg), a mandible (Clark), with a small quantity of confused material (Palæoniscus, Dipterus, Acanthodes and a Pristacanthus) compose the fauna of these groups, while the Chemung, through the labors of Randall, Beecher, Sherwood and Lilley, has yielded a somewhat larger and more promising fauna, in Heliodus, Dipterus, Sphenophorus, Holonema, Ganorhynchus, Phyllolepis, a Dinichthys, an Onychodus and the more characteristic Holoptychius and Helodus. Lastly, the Catskill, almost entirely barren of other fossils, except in its lower portion, holds in most places the plates of Holoptychius, Bothriolepis, Sauripteris, Glyptopomus, Dipterus and Gyracanthus. For details see the table of fossils from the Ohio shale.

Vertebrates of the Devonian in Ohio.

[Note.—For explanation of references see page 243.]

	Oriskany.	Corniferous.	Cornit.-Ham.	Huron Shale.	Erie Shale.	Cleveland Shale.
Elasmobranchs.						
Machaeracanthus major Nby	......	abd	abd	......	......	......
M. sulcatus Nby	......	......	abd	......	......	......
M. peracutus Nby	......	......	abd	......	......	......
Oracanthus fragilis Nby‡	......	......	b	......	......	......
O. abbreviatus Nby‡	......	......	b	......	......	......
O. granulatus Nby‡	......	......	b	......	......	......
O. multiseriatus Nby‡	......	......	b	......	......	......
Psammodus antiquus Nby	......	......	h ?	......	......	......
Cyrtacanthus dentatus Nby	......	......	a	......	......	......
Ctenacanthus vetustus Nby	......	......	ad	......	......	......
Ct. (Hoplonchus) parvulus Nby	......	......	......	......	......	ad

* American Geologist, 1893.

† Claypole. Amer. Geologist, 1893.

‡ =Acantholepis, see d. p. 33.

	Oriskany.	Corniferous.	Cornif.-Ham.	Huron Shale.	Erie Shale.	Cleveland Shale.
Ct. compressus Nby						ed
Ct. clarki Nby						d
Ct. wrighti Nby			dl			
Ctenodus Dip. wagneri Nby						d
Phoebodus politus Nby						d
Orodus elegantulus Nby†						a
Polyrhizodus modestus Nby†						a
Apedodus priscus Leidy						d Ch
Gyracanthus sherwoodi Nby						d Cat
Goniodus hertzeri Nby				d		
Cladodus concinnus Nby					ad	
Cl. sinuatus E. W. C.						c
Cl. rivi-petrosi E. W. C.						c
Cl. clarki E. W. C.						c
Cl. terrelli Nby						d
Cl. tumidus Nby						d
Cl. parvulus Nby‡						a
Cl. kepleri Nby						d
Cl. fyleri Nby						d
Cl. carinatus Nby					d Ch	
Cl. pattersoni Nby						a‡
Monocladodus clarki E. W. C.						c
M. pinnatus E. W. C.						c
GANOIDS.						
Macropetalichthys sullivanti Nby		abd	abd			
Asterosteus stenocephalus Nby		abd	abd			
Actinophorus clarki Nby						d
Holoptychius ? pustulatus Nby					d Ch	
H. granulatus Nby					d Cb	
H. tuberculatus Nby					d Ch	
H. ? giganteus Ag.					d	Cat
H. americanus Leidy						d Cat
H. halli Nby						d Cat
H. ? radiatus Nby						d Cat
Phyllolepis delicatula Nby					d Ch	
Heliodus lesleyi Nby					d Ch	
Dipterus nelsoni Nby					d Ch	
D. flabelliformis Nby					d Ch	

† See note b. ‡ See note a.

	Oriskany.	Corniferous.	Cornif.-Ham.	Huron Shale.	Erie Shale.	Cleveland Shale.
D. levis Nby					d Ch	
D. minutus Nby					d Ch	
Oncyhodus sigmoides Nby		ad	ad			
O. hopkinsi Nby					d Ch	
O. ortoni Nby				d		
Sphenophorus silleyi Nby					d Ch	
Dipterus sherwoodi Nby						d Cat
D. radiatus Nby						d Cat
Sauripteris taylori Hall						Cat
Glyptopomus sayrei Nby						d Cat
Placoderms.						
Liognathus spatulatus Nby			a			
Coccosteus occidentalis Nby			ad			
Dinichthys hertzeri Nby				ad		
D. terrelli Nby						ad
D. clarki E. W. C						c
D. gracilis E. W. C						cf
D. gouldi Nby						d
D. curtus Nby						d
D. intermedius Nby						d
D. corrugatus Nby						d
D. minor Nby						de
D. ? praecursor Nby	d					
D. lincolni E. W. C			c*			
D. newberryi J. M. C				g*		
D. ringuebergi Nby				h*		
D. canadensis J. F. W						
D. tuberculatus Nby					d*	
D. eifelensis Kayser						
Gorgonichthys clarki E. W. C						cf
Coccosteus cuyahogae E. W. C						cf
Titanichthys clarki Nby						ad
T. agassizi Nby						ad
T. attenuatus Wright						f
T. rectus E. W. C						cf
Stenacanthus niticans Leidy=B. leidyi						m*
Glyptaspis verrucosa Nby						d
Diplognathus mirabile Nby						d
Mylostoma terrelli Nby						de
M. variabile Nby						de
Trachosteus clarki Nby						d

	Oriskany.	Corniferous.	Cornif.-Ham.	Huron Shale.	Erie Shale.	Cleveland Shale.
Holonema rugosum E. W. C	......	......	......	......	dk*	......
Ganorhynchus beecheri Nby	......	......	......	......	d	......
Aspidichthys clavatus Nby	......	......	......	ad	......	......
Bothriolepis leidyi Nby	......	......	......	......	......	d*
B. minor Nby	......	......	......	......	d*	......
Callognathus regulare Nby	......	......	......	......	......	d
C. serratus Nby	......	......	......	......	......	d
Brontichthys clarki E. W. C	......	......	......	......	......	c
CEPHALASPIDS						
Acanthaspis armata Nby	......	ad	ad	......	......	......
Acantholepis pustulosa Nby	......	ad	ad	......	......	......
CHIMEROIDS						
Rhynchodus secans Nby	......	ad	ad	......	......	......
Rh. frangens Nby	......	ad	ad	......	......	......
Rh. crassus Nby	......	ad	ad	......	......	......

NOTE A.

Cladodus pattersoni.

This species, a small jaw with teeth from Vanceburg, Ky., is described in the Palaeontology of Ohio, (v. ii, p. 47), and referred to the "Waverly Black Shale." As its horizon seems rather uncertain it has been inserted here. No black shale is apparently recognized on that horizon by the Kentucky geologists (see *Geol. of Ky.*, vol. iii, p. 171), and as *the Black shale* is close to the spot indicated it is possibly the stratum intended. See also *Geol. of O.*, vol. ii, p. 624.

NOTE B.

Orodus elegantulus.

Polyrhizodus modestus.

Cladodus parvulus.

These three species are described in the Palaeontology of Ohio, but are omitted from the Monograph, whence the inference is legitimate that they were considered invalid by their author.

* The fossils marked with an asterisk were found in the eastern part of the basin and are allotted to the horizon in the tables for convenience without any insistence on their exact correlation which the data do not usually permit. Speaking generally, however, the reference is as close to accuracy as our present knowledge allows.

DETAILS OF THE GENUS DINICHTHYS SHOWING MATERIALS PUBLISHED TO DATE 1894.

SPECIES OF DINICHTHYS.	Author.	Date.	Reference.	HORIZON.	Mandible.	Premaxillary.	Cranium.	Supra-scapula	Suborbital.	Dorsal.	Scales.	Ventral.	Supra-occipital.	Scleroticplates.	Sheartooth.
Dinichthys hertzeri	Nby	1873	ad	Huron Shale O.	x	x	pt	x	......	x	......	?	......	......	x
Dinichthys terrelli	Nby	1873	ad	Cleveland Shale O.	x	x	x	x	x	x	......	x	x	......	x
Dinichthys minor	Nby	1878	ed	Cleveland Shale O.	pt	x	......	......	......	x	......	......	x	......	......
Dinichthys gouldi	Nby	1889	d	Cleveland Shale O.	x	x	x	x	x	x	......	......	x	x	......
Dinichthys corrugatus	Nby	1889	d	Cleveland Shale O.	x	......	......	......	......	......	......	......	......	......	......
Dinichthys intermedius	Nby	1889	d	Cleveland Shale O.	x	x	x	x	x	x	......	x	x	x	x
Dinichthys curtus	Nby	1889	d	Cleveland Shale O.	x	......	x	x	x	......	......	x	......	x	......
Dinichthys gracilis	Clay	......	fc	Cleveland Shale O.	x	......	pt	......	x	......	......	......	......	......	......
Dinichthys clarki	Clay	1893	c	Cleveland Shale O.	......	x	......	......	......	......	......	......	......	......	......
Dinichthys praecursor	Nby	1889	d	Cornif. limestone O	......	......	......	......	......	x	......	......	......	......	......
Dinichthys newberryi	J. M. C.	1885	g	Hamilton, N. Y.	......	......	......	......	......	......	......	......	......	......	......
Dinichthys ringuebergi (minor)	E. S. R	1884	h	Portage, N. Y.	......	......	......	......	......	x	......	......	......	......	......
Dinichthys tuberculatus	Nby	1888	d	Chemung (Belgium), Pa	......	......	......	x	......	x	......	......	......	......	......
Dinichthys canadensis	J. F. W	1890	i	Devonian, Man., Can.	......	......	x	......	......	......	......	......	......	......	......
Dinichthys eifelensis	Kays	1880	j	Devonian, Belgium	......	x	......	......	......	......	......	......	......	......	......
Dinichthys lincolni	Clay	1893	c	......	......	......	x	......	......	......	......	......	......	......	......

[To be continued.]

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The Report of the [New York] State Paleontologist for the year 1902. (Bulletin No. 69, N. Y. State Museum, Albany, 1903.)

This document contains, besides the administrative report by the State Paleontologist (p. 852-889), a considerable number of original contributions on the New York formations and their fossil contents. These are:

1. The Dwarf Fauna of the Pyrite Layer at the Horizon of the Tully limestone in western New York, by F. B. Loomis (p. 890-920, 5 plates), describing a peculiar stunted Hamilton fauna.

2. Mastodons of New York, a list of Discoveries of their Remains, 1705-1902, compiled by J. M. Clarke (p. 921-933, 2 plates).

3. The Cambric Dictyonema Fauna in the Slate Belt of Eastern New York, by R. Ruedemann (p. 934-958, 3 plates), in which the discovery in eastern New York of a graptolite horizon characterized by Dictyonema flabelliforme, and forming the closing stage of the Upper Cambric in northern Europe and Nova Scotia, is announced.

4. On the Sedimentary Impression of the Animal whose Trail is known as Climactichnites, by Jay B. Woodworth, (p. 959-966, 2 plates). In this paper are described some gigantic tracks with terminal impressions, supposedly of a large mollusk, which have recently become known from the Potsdam sandstone of northern New York.

5. Devonic and Carbonic Formations of Southwestern New York, by L. C. Glenn (p. 967-989, with stratigraphic map of the Olean quadrangle. This paper is supplemented by a paleontologic contribution on Fossil Faunas of the Olean quadrangle by Charles Butts (p. 990-995).

6. The fact that the above cited papers give different interpretations of the Olean section on account of the different modes employed, has led to a discussion of the principles involved by the State Paleontologist in the next succeeding paper, entitled Contribution on the Olean Rock section (p. 996-999).

7. The Stratigraphy of the Portage Formation between the Genesee Valley and Lake Erie is the title of a paper by D. D. Luther (p. 1000-1029, 1 map), giving much new information on the Upper Devonic shales of western New York.

8. The Stratigraphy of Becraft Mountain, Columbia county, N. Y., by A. W. Grabau (p. 1030-1079, with stratigraphic map and sections). A contribution describing in great detail that interesting Devonic outlier, its constituent formations and included faunas and especially its much faulted structure.

9. A new Eurypterid Fauna from the Base of the Salina of Western New York, by Clifton J. Sarle (p. 1080-1108, 21 plates), contains the description of some new and most interesting eurypterids from the basal black Salina shales in the vicinity of Rochester, one of them representing a new genus, Hughmileria, the remaining being new species of Eu-

rypterus and Pterygotus and some remarkable crustacean remains of problematic position.

10. Preliminary Observation on the Cobleskill (Coralline) Limestone of New York, by C. A. Hartnagel (p. 1109-1175); the first installment of the results of detailed investigations undertaken by the author for the purpose of establishing the exact position and relations of certain beds lying in eastern New York between the Lorrain shales and Lower Helderberg beds, which, like the "Coralline" limestone have hitherto been but broadly correlated with the standard series.

11. Disturbed Fossiliferous Rocks in the vicinity of Rondout, N. Y., by G. van Ingen and P. Edwin Clark (p. 1176-1227). This contribution has, for its first object, a description of the series of Siluric and Lower Devonic beds of the Rondout region, and attempts further to unravel the very complex tectonic structure in which these rocks have been involved and which has been well exposed by the extensive cement mining. As the main structural features of the region are recognized a sigmoid flexure on the Vlightberg, which is an underfold toward the northwest, an overthrust of the upper layers of the crest of the arch; and an extensive overthrust of typical Appalachian characters in the hills adjoining north.

12. The Torsion of the Lamellibranch shell, recently propounded by Noetling as an important criterion for phylogenetic investigation, is demonstrated in a paper by the State Paleontologist (p. 1228-1233, 2 diagrams and 6 figures) to be also an important ontogenetic character in some forms, and it is by means of such ontogenetic observation concluded that the condition of the Protoconchae, or the most primitive group of Lamellibranchs, postulated by Noetling, is found in the prodissoconch.

13. The same author (p. 1234-1238, 2 plates) describes two forms of Chætopod worms, from the Upper Devonic beds of western New York, one of which, Protonympha salicifolia, is allied to Aphrodite, the other, Palæochæta devonica suggests Phyllodoce or Nereis.

MONTHLY AUTHOR'S CATALOGUE
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Geology of Monroe county. (Iowa Geol. Sur., vol. 13, pp. 356-423, map, 1903.)

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CORRESPONDENCE.

Glacial Lake Jean Nicolet. Through an oversight which I much regret, in an article contributed by me to the last August number of the American Geologist, the name *Lake Nicolet*, applied to the glacial lake of the upper part of the basin of the Fox river, in Wisconsin, duplicates, except for a slight difference of orthography, the name *Lake*

Nicollet, before given by professor N. H. Winchell, (in Bulletin G. S. A., vol. xii, p. 122, February, 1901) to a glacial lake that covered the sites of Leech, Winnibigoshish, and Cass lakes, in Minnesota, near the source of the Mississippi river. Professor Winchell, when my article was published, was absent, and at his return he called my attention to the duplication. The name given by him is in honor of Joseph Nicolas Nicollet, while that proposed by me commemorates Jean Nicolet, who lived two hundred years earlier and was the first white explorer in Wisconsin. Therefore, I wish to suggest, for discrimination of these similar names, that the Wisconsin glacial lake, described and named by me, be called *Lake Jean Nicolet*. WARREN UPHAM.

St. Paul, Minn., October 10th, 1903.

PERSONAL AND SCIENTIFIC NEWS.

FRANK S. MILLS has accepted the professorship of geology at St. Lawrence University, Canton, New York.

W. H. DALL is about to enter upon the study of the Pacific coast Tertiary, having substantially finished the Atlantic coast Tertiary.

DR. F. A. WILDER, late state geologist of North Dakota, has accepted a professorship of geology in the State University of Iowa.

E. R. CUMMINGS, Ph.D., has been appointed acting head of the department of geology at the University of Indiana, at Bloomington.

DR. A. G. LEONARD, ASSISTANT STATE GEOLOGIST OF IOWA, has accepted the position of professor of geology in the University of North Dakota.

EDWARD HOIT NUTTER has recently accepted the associate editorship of "Mineral Wealth," monthly mining and engineering journal of northern California.

DIRECTOR C. D. WALCOTT was recently in Minneapolis in conference with President Northrop of the State University on some educational interests of the survey.

PROFESSOR J. A. UDDEN has returned to Rock Island, where he will continue his former work, having been engaged temporarily on the Texas University Mineral Survey.

PROFESSOR E. C. PERISHO, of the Platteville (Wisconsin) Normal School, has been elected professor of geology in the State University of South Dakota and also state geologist.

JAMES M. HYDE, formerly curator of the California State Mining Bureau Museum, San Francisco, has recently been appointed Assistant Professor of Geology and Mining in the University of Oregon.

DR. H. P. KÜMMEL, state geologist of New Jersey, is dangerously low with typhoid fever at Lake-Side hospital, Milwau-

kee, Wis. The disease was contracted in the Wasatch mountains in September.

SIR ARCHIBALD GEIKIE'S "Text-book of geology" has just appeared in its fourth edition, which consists of two volumes including nearly 1500 pages. It is published by the Macmillan company. The third edition of this standard text-book appeared in 1893 and included about 1160 pages.

DR. R. A. DALY, of the Canadian international boundary commission, returned to Ottawa recently from the field work in the Rocky mountains. He reports having made a very interesting and successful series of observations on the igneous rocks of the region and their relations to the clastics.

PROFESSOR J. E. TODD has recently resigned his position as professor of geology and mineralogy in the University of South Dakota, which he has held for over eleven years. He consequently also ceases to be state geologist. Dissatisfaction with the administration of the university is his reason for so doing.

PROFESSOR W. O. CROSBY was engaged during the first part of the summer in the examination of samples from borings in Long island for the U. S. Geological Survey. The last two months he devoted to the mining geology of the Klondike and Nome districts of Alaska. He returned to Boston September 30th.

DR. W. W. WATTS chose as the subject of his address, before the last meeting of the geological section of the British Association for the Advancement of Science, "The functions of geology in education and in practical life." The address is of particular interest to teachers in colleges and in technical schools and is published in *Science* for October 9, 1903.

WILLIAMS HALL, OF LEHIGH UNIVERSITY, South Bethelhem, Pa., formally opened Oct. 8, has three floors, each containing over twelve thousand square feet. One-half of the building is to be devoted to the department of geology, and the other half to the department of mechanical engineering. It is named from professor E. H. Williams, the principal donor, now of the department of geology and mining.

LAKE LEVEL COMMISSION. President Roosevelt has appointed the following as the American members of the international commission to investigate the level of the great lakes, and to determine whether the level is influenced by the deepening of the channels, the changing of water courses and the construction of artificial waterways, viz.: Col. H. O. Ernst, corps of engineers; Prof. G. S. Williams, Cornell University; and Mr. George Clinton, of Buffalo, N. Y.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, GEOLOGICAL DEPARTMENT. With three new men, and the work of each specialized along definite lines, the efficiency of the department

is much strengthened. Professor W. O. Crosby and Dr. D. W. Johnson have charge of the economic and structural geology; Dr. C. H. Warren is instructor in mineralogy and petrography; Mr. H. W. Shimer is instructor in paleontology and stratigraphic and physiographic geology; Mr. G. F. Loughlin is assistant in geology and has charge of some of the petrography. Professor T. A. Jaggar of Harvard University gives, during the first term, a course in general geology.

THERE IS EVERY REASON TO BELIEVE that future years will see a notable expansion of mining in China. The country has two important advantages in possessing a network of rivers and canals which afford a splendid system of water-ways, and it is in a position to afford an abundance of cheap labor. In this regard it stands in violent contrast to several regions where the mining industry has made much greater strides. The walking delegate has not as yet met the mandarin; when these two forms of misrule meet the sparks will fly; but we trust that before that consummation arrives both will have gone the way of the dodo, the mammoth and other things unfit to survive.—*Eng. and Min. Jour.*

MONT PELÉE. The remarkable new feature in the history of Mt. Pelée, on Martinique island, is the ascending cone or spine, described by Heilprin and Lacroix, and first illustrated by Hovey, in the *New York Herald* for April 19, 1903. This spine rises above the northwest quarter of the old crater, and its base is surrounded by a valley on the outer sides of which is a ridge which constitutes the new cone or crater. The old crater rim is still outside and is separated from the new by a rather shallow valley or gorge. The great spine constitutes a part of the northwest rim of the new crater, and in April was estimated to rise 1000 feet above its own base and 5000 feet above the sea. It is of solid rock, and is apparently rising bodily from the interior of the volcano.

THE THIRD ANNUAL INTERCOLLEGIATE EXCURSION in New England was held at Meriden, Conn., on Saturday, Oct. 17, under the guidance of Professor H. E. Gregory of Yale University. The largest delegations of students were from Yale, under Profs. Gregory, Pirsson and Barrell, and from Wesleyan, under Prof. Rice. Harvard, Wellesley, Amherst, Smith and Williams were also represented, as well as a number of secondary schools. Over one hundred persons took part in the excursion, driving about the Hanging Hills district in large wagons. The geological results of the trip were unfortunately diminished by fog on West Peak, and by several heavy showers in the lowland; but the general structure of the region was pointed out, the double lava flow in the Meriden quarry was well seen, and several of the faults by which the region is divided into long, narrow blocks were demonstrated.

United States Geological Survey. A report on the gypsum resources of the United States, which will include a considerable report on the gypsum deposits of New York, has been prepared by Mr. E. C. Eckel and will be issued in the near future as a bulletin. A report on the salt deposits of that state is also in preparation and will be issued early in 1904.

The areal mapping of the Juneau special quadrangle (Alaska) has been completed by Dr. A. C. Spencer, assisted by Mr. C. W. Wright, and a study of the ore bodies of that district (Treadwell mine) has been begun.

Mr. Alfred H. Brooks, who has charge of the Alaskan work for the survey, will return to Washington about the end of October.

In co-operation with the State of New York, the Survey has recently issued a group of six topographical maps covering the quadrangles of Raquette Lake, Gloversville, Big Moose, Blue Mountain, Northport and Phœnicia, lying within portions of Hamilton, Fulton, Herkimer, Essex, Delaware, Ulster, Green, Suffolk and Nassau counties. The Raquette Lake quadrangle includes a number of the typical lakes and mountains of the Adirondack district, and the Northport quadrangle includes part of the Long Island shore line.

In Texas the topographical map of the Burnet quadrangle has just been published, and a new edition of the map of the Blanco quadrangle has also been issued.

In Ohio topographic maps of the Findlay, Fosteria, Oberlin, Canton and Massilon quadrangles have just been issued.

In California the Tejon quadrangle is now published.

The Brownsville-Connellsville geologic folio (No. 94) will soon be ready for distribution. In this the great Pittsburg coal bed is described.

Water Supply and Irrigation papers soon to be issued are No. 87, which is an enlarged and revised edition of the report on irrigation in India by H. M. Wilson, and No. 88, which is a report on the Passaic (New Jersey) river flood of 1902, written by G. D. Hollister and M. O. Leighton.

"Contributions to the geology of Washington," is the title of Professional Paper No. 19, which is about to be issued. This is by Bailey Willis and George Otis Smith.

The total production of coal, coke, petroleum, zinc, lead and monzanite in the United States during 1902 is as follows: coal, 300,930,659 short tons, of which 41,289,595 was anthracite; coke, 25,401,730 short tons; petroleum, 80,894,500 barrels, being over 45 per cent of the total output of the world; zinc, 156,927 short tons; lead, 270,000 short tons; monzanite, 982,000 pounds, which came exclusively from North and South Carolina.

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THE DEVONIAN ERA IN THE OHIO BASIN.*

By EDWARD W. CLAYPOLE.

V. ANCESTRY OF THE DEVONIAN VERTEBRATES OF THE APPALACHIAN GULF.

Throughout the vast strata of Cambria, Ordovicia and Siluria, with all their crowded fossil forms, only the scantiest traces have been found in America of fossils that indicate vertebrate affinity. Such remains have long been known in Europe where, especially in England, different species of the pteraspidians are abundant in the uppermost Silurian beds The discovery, therefore, by the writer in 1883 of similar fossils (Palæaspis) in rocks of the Salina group in middle Pennsylvania was of great interest by establishing a correlation of the strata on both sides of the Atlantic in this respect. Indeed, the oldest of the specimens there found and described by myself,† coming as they did from the Clinton strata, are of somewhat older date than even *Scaphaspis ludensis* of England, the solitary specimen yet known from the Lower Ludlow of that country. But the Pteraspis, Scaphaspis, Holaspis, etc., of the east and the Palæaspis of the west are so closely alike that they must also be as closely allied. At the same time their structure is so peculiar and so different from that of any other fish, that it is difficult to trace any line of genetic connection between them and their successors. If connecting links exist they must exist elsewhere, for their occurrence in the Ohio basin, though still possible, is scarcely probable.

* Continued from page 322.

* *Quart. Jour. of the Geol. Soc. of Lond.*, 1885 and 1892.

These Pennsylvanian fossils are the oldest indications of vertebrate existence that the rocks have yet yielded, regarding whose nature and horizon no doubt can be entertained. The reported discovery some years ago of fossil fishes in Ordovician strata in Colorado, on which a paper was read before the International Congress of Geologists, at Washington, in 1891, is apparently too uncertain for confidence and its accuracy must be considered as questionable.*

After very careful examination of specimens from the locality and as much study of the stratigraphy as can well be made at second hand, I can not avoid the conclusion, forced upon me by microscopic and other study of the fragments of bone and comparison of the published figures, that these fossils are *Devonian* in age and must be correlated with others of that era and that the red sandstone in which they occur corresponds with the well known Old Red sandstone of Scotland and has been in some way displaced and possibly overthrown by faults and thrusts. The stratigraphy of the region is manifestly complex and much disturbance has taken place, rendering the utmost caution necessary and the most rigid proof indispensable.

VI. ON THE PERSISTENCE OF FAUNAS IN THE DEVONIAN.

The facts that were given in a previous section illustrate strongly the danger of too close a correlation of non-adjacent areas, even when separated by no very long distance. The characteristic Marcellus fauna of New York appeared in the thin shaly bed found by Whitfield near the middle of what had been considered the Corniferous limestone in Ohio, and is succeeded above by a profusion of typical Corniferous fossils, which are not known on a similar horizon in New York. The obvious inference is that, while the Marcellus fauna occupied the inner part of the Appalachian gulf to the exclusion of the Corniferous species, the latter were predominant in the mouth of the same gulf. It is further to be inferred that small and

* In spite of the apparent connection of the argument in Mr. Walcott's paper, much closer and more cogent reasoning will be required to convince palæontologists of the Ordovician age of the fossils and to overcome their repugnance to setting back so far at a bound the epoch of the commencement of vertebrate existence. The sections, too, must be more strictly connected with one another and the absence of any disturbances and irregularities ensured.

occasional minglings of the faunas took place on the neutral territory between their two special places of permanent abode, and further still, that conditions allowing of these interminglings endured throughout the time required for the deposition of thirty or forty feet of nearly pure limestone in Ohio, or during all the upper part of the Black shale and probably a considerable portion of the succeeding Hamilton in the east. These faunas, then, were not successive, as often supposed, but really contemporary, and must be distinguished, not by their horizon, but by the sediment in which they are found, the latter being apparently the determinant condition.

Evidently a good and characteristic Corniferous fauna lived on in Ohio through the whole Marcellus period and until the Hamilton was far advanced, if not nearly complete, in Pennsylvania and New York, thus bringing the Lower Devonian (Corniferous, Marcellus, Hamilton) species up almost to the base of the Upper Devonian (Tully?, Chemung, Catskill). It did not finally fail until the permanent change in the nature of the sediment, from argillaceous to arenaceous, rendered longer tenure of the ground impossible, save to those forms which could adjust themselves to the new conditions. Further west, where a similar change is unknown, it is not possible to determine how long the Corniferous fauna presisted before it could be said to have entirely changed its facies to that of the Hamilton. The 50 to 100 feet of calcareous shale, of which the whole Devonian series there consists, is marked by changes so slow and minute that all sub-division has proved impracticable. When longer study and larger collections more carefully located by the geologists of the west shall have given us the whole life-history of the period, we shall probably be enabled to trace the evolution along the lines of species and to recognize the slow changes of form and fauna from horizon to horizon.

There is no difficulty in ascertaining where each of the two faunas held its headquarters while thus mutually and alternately invading the middle ground. The Corniferous fauna evidently maintained itself in the open sea to westward, where clear water and calcareous deposits continued uninterrupted, while the Marcellus and Hamilton faunas tenanted the shores and the shallows, whose wash kept the water clouded and the bottom muddy. An inquiry into the origin of the Marcellus and

Hamilton faunas would be a problem too large and too wide-reaching for introduction here. But most probably both came from the east and both had most likely been in existence on the eastern shore of the Appalachian gulf during no small part of the previous period. The almost complete destruction of the shore-line that has since taken place renders it impossible at present to detect and to prove this contemporaneity, but there can scarcely be a doubt that the Marcellus fauna overlapped downward in the east, in some places where favorable conditions prevailed, even during the Corniferous period, since it must have had both time and place for development before it emerged; and we shall later see that it continued upward long after the Marcellus period had closed.

As a further illustration of the same principle of the persistence of the faunas in the Devonian era, we quote professor Hall, who writes: *

"At Ithaca, where we are far above the Tully limestone, and where the rocks are well marked by an abundance of fossils peculiar to themselves, we still find *Microdon bellistriatus, Mociola concentricus* and some others, and I have even detected *Calymene bufo* and *Dipleura dekayi* in the same association."

These are all Hamiltonian species in New York, and yet they occur far above their normal limits and indicate a similar persistence of some members of that fauna to much later times. Reverting to the Marcellus, professor Hall remarks of the fossils of the Genessee shale: †

"The three species here figured *Avicula (Lunulicardium) fragile, Strophomena (Chonetes) setigerus, Tentaculites (Styliola) fissurella* are common to this rock and the Marcellus shale, the lithological character of the two being precisely similar. Neither of them has been noticed in the intervening rocks of the Hamilton group, though the Avicula passes upwards into the Cashaqua Shale of the Portage group. This is an interesting example of the recurrence of the same species of fossils in rocks widely separated from each other."

This observation of professor Hall carries three of the Marcellus species up through the Hamilton (though not yet found), through the Tully and into the overlying Genesee. Professor H. S. Williams in a paper read before the American Association for the Advancement of Science, at Cincinnati,

* *Geology of the Fourth District of New York*, p. 217.

† *Op. cit.*, p. 222.

in 1881, gives yet greater range to some members of the Marcellus fauna. He concludes:

"1. That the same fauna, which was well defined in the Marcellus shale recurs with very slight modification in the Genessee shale and the Ithaca shale of New York.

2. That this recurrent fauna of New York is the same fauna which characterizes the Black shale of Ohio, Kentucky, Indiana, etc., and other regions in the interior of the continent.

3. That the fauna was a single continuous fauna and during the early and middle Devonian age its centre was located to the southward and westward of New York."

Regarding the first of professor Williams's conclusions there is no ground for disagreement. The facts quoted by him and others, which have come to light since 1881 afford ample proof of its truth. But the second does not appear to be equally well founded. The molluscan fauna of the Black shale of Ohio, etc., is far too scanty to justify the deduction.

Another illustration of this recurrence of species with the recurrence of congenial conditions may be quoted from Pennsylvania. The genus Rensselæria, with all its forms and subdivisions, is especially abundant in the Oriskany sandstone, but disappears with the replacement of this material with shale in the Marcellus and Hamilton strata. In middle Pennsylvania, however, the medial mass of the Hamilton is a coarse, thick sandstone, and with this reappears the genus Rensselæria (Newberria). This raises the question, as in the cases quoted by professor Williams, "Where had the genus resided during the interval when the conditions were uncongenial?" It would seem most reasonable to think that the place of its retreat was at no very great distance and, apparently, it must have been near the shore line of that day, as only there could it find the kind of bottom in which it seems to have delighted. The solution of this problem is possibly more dependent upon geographical extension and migration than upon succession in time.

VII. ABUNDANCE OF PETROLEUM AND SCARCITY OF FOSSILS IN THE SHALE.

The abundance of petroleum and the great scarcity of fossils in the Black shale are facts that point in two directly opposite directions. The former is indisputable evidence of the abundance of organic matter, and therefore, of organisms liv-

ing at the time of the accumulation of the material, from which petroleum arose as a secondary product, and the latter is, at first glance, an indication, at least, of their absence. There is only one way of reconciling these two conflicting pieces of testimony. That is to allow that the fossil memorials of the life of the shale sea have been in some way or other destroyed.

That the petroleum is an organic derivative is presumably beyond question. No other probable source has ever been indicated. The theory of an inorganic origin advocated by Mendeléef has no geological or even chemical basis, and would never have attracted notice save for the great name and fame of its author. But whether this hydrocarbon is of animal or vegetable nature is a question less easily answered. Dr. Newberry advocated the latter and likened the water in which the black shale was laid down to the Sargasso sea of the present Atlantic, admitting, however, that in some cases and to some extent animal remains might have contributed their share to the result. This latter view seems the only probable and tenable one. The vast amount of material required is inconsistent with any other source. As for the fishes, etc., which inhabited the sea, if the order of nature was then as it is now, probably few of them were ever allowed to decay. Their carcasses would be promptly eaten by some of their comrades, even if the animals were permitted to die a natural death, which is scarcely likely, save perhaps in the case of some monster such as Dinichthys. But the vast accumulation of vegetation yearly dying and decaying must have supplied to the bottom an enormous mass of carbonaceous material, to which the blackness of the shale may well be due.

This conclusion seems to require a very slow rate of accumulation for the shale, and this is in exact agreement with its extreme fineness and with the known distance from land. To include ten per cent of carbonaceous matter in its composition must have demanded many years of vegetable decay during the accumulation of a very small thickness of the shale. This inference is, moreover, in harmony with the already noted lack of fossils, for, except in a limestone sea, fossils are best preserved where deposit is rapid. In a shale, sea lime must be scarce and it is only a logical deduction that the shells, etc., lay on the surface unburied long enough to allow of their

complete solution in the water. Their lime would in that case have afforded material for another generation and no trace of their past existence would remain. As in confirmation of this opinion, I have often found in the Chemung strata of Pennsylvania the casts of single valves of brachiopods and lamellibranchs suggesting that the fossil was the impression rather of an epidermis of a solid shell, the latter having apparently been dissolved away before fossilization took place. Only occasionally in such circumstances would the preservation of the organic remains of the time be possible.

The abundance of pyrites diffused through the mass is another reason for believing that organic remains are not lacking in the Black shale in consequence of original absence. In some cases this mineral is so abundant as to earn for the beds the name of alum-shales or schist. This fact also lends support to the belief that the accumulation was very slow, inasmuch as the iron sulphide is regarded as one of the derivatives of animal decay.

That fishbones should be preserved in so great perfection in the almost total absence of all other fossils is again a fact in the same line. These parts, consisting chiefly of phosphate of lime are not subject to the same laws of solution as are the shells of Mollusca, composed of the carbonate. A further fact tending in the same direction is that almost the only molluscan remains in these black shales are those of the genera Lingula and Discina, with their allies. These contain little or no lime, and could, like the fish plates, resist the solvent powers of the water and endure until they were buried in sediment. The excessive abundance of these horny shells in certain layers renders it difficult to believe in the total absence of every other kind. Mud-loving lamellibranchs are far from scarce.

We cannot enter into the mixed chemical question of the exact methods of production of petroleum and the other hydrocarbons found in like situations. They are apparently in the main, similar to those which develop marsh-gas when vegetable matter is buried under water, without decaying. But the nature of the petroleum is frequently in accord with that of the shale, the black heavy oil being the product of the Black shale while the lighter and redder oils of Pennsylvania, rich in kero-

sene, come for the most part from shales that are less black and more sandy, as is the Chemung of that state.

VIII. THE PALAEOBOTANY OF DEVONIAN APPALACHIA.

Very few lines will suffice to sum up the knowledge of the palæobotany of Appalachia in the Devonian era.

The Oriskany has nowhere yielded any traces of fossil plants.

From the Corniferous, we as yet know only a few forms. Two were reported by Newberry* from the Corniferous-Hamilton group at Delaware. They are the trunks of two species of tree ferns which were previously described by him as *Caulopteris antiqua* and *C. peregrina.*† A lepidodendrid stem completes the scanty list. This was said to most nearly resemble *L. gaspianum.*

The occurrence of these fossils in the place where they were found was urged by Dr. Newberry as a strong reason for believing that the island of Cincinnati was at the time above the sea-level; for he considered it in a very high degree improbable that such vegetable remains should have been drifted together from the shore of the Appalachian sea 500 miles distant. The argument has lost none of its cogency since his day

In the overlying Huron Black shale are frequently found logs of silicified wood and many of its beds abound with the little fossil named by Sir. Wm. Dawson, *Sporangites huronensis.* The latter is sometimes so abundant as to give the black surface of the shale a resinous yellow tinge. If the remains are really the spores of terrestrial rhizocarps these must have been excessively abundant on some adjoining land. If they were marine, the sea must have been, as Dr. Newberry suggested, a veritable Sargasso. In either case the plants must have been remarkably fragile; for no specimen of either stem or leaf, with one or two doubtful exceptions, has yet been discovered.

The second kind of vegetable fossil that is found in the shale,—the woody trunks,—has been named *Dadoxylon.* Microscopic examination of the structure has led to the opinion

* *Geology of Ohio*, vol. i, 1873, pp. 106-146.

† *Quart. Jour. of the Geol. Soc. of Lond.*, 1871, p. 272.

that they were coniferous in their nature and the date of the conifers has accordingly been carried back to the earlier part of the Devonian era. But it seems on the whole, much more probable that they really belonged to the extinct family of the Cordaiteæ. No trace of any foliage resembling that of the conifers has ever been found in the same strata with the trunks; whereas the broad strap-like leaves of Cordaites are of frequent occurrence. Solms Laubach refers Dadoxylon to Araucarioxylon, and Araucarioxylon is now known to be the wood of Cordaites, so that the probability becomes almost a certainty that the fine leaved pines and firs must be omitted from Devonia and the broad, thin foliage of the now vanished Cordaites must be substituted. When some fortunate geologist succeeds in finding the characteristic fruit of this family all doubt will be removed. I have similar leaves from the Cleveland shale, indicating the existence of like species on that horizon.

Beyond the minute Sporangites already mentioned, the Marcellus has yielded almost no recognizable vegetable remains and the same is, in general, true of the Devonian strata below it in the east. In the Hamilton there are stronger indications of both marine and terrestrial vegetation,* but even here the list is not long. Lepidodendron was represented by its earliest known species, *L. primaevum* from Huntington, Pennsylvania, described in the report of the First Survey. *Sigillaria halli* is probably an error, the genus being of later origin, at least in the United States. Dawson's Psilophyton has been reported from New York. Traces of the broad, flat leaves of Cordaites are occasionally met with and a few doubtful and broken fern-fronds and a Calamite (*Bornia transitionis*) nearly complete the list of terrestrial species, setting aside indistinct and indescribable fragments. The fossil wood of Eighteen-mile creek in New York belongs with that of the Ohio shale. This has already been discussed and Rhachiopteris, Syringoxylon and Psaronius are probably the stems of some of the other plants bearing other names.

Nor has the Hamilton been very productive of seaweeds. The ambiguous form Ptilophyton, or Lycopodites, if belonging in this part of the kingdom at all, is the best preserved fossil of

* The works of SIR WILLIAM DAWSON and PROF. LESQUEREUX are referred to for details.

its kind in middle Pennsylvania and is so common in the Hamilton upper shale (among its extensive marine fauna) that its very abundance in the absence of every other known form of plant, except Spirophyton (*Taonurus*), is sufficient to awaken suspicion of its vegetable nature.

Some other imperfect specimens are referred to various genera and species in the works indicated above but little or nothing is known of them within our district. In Canada, a larger flora is credited to the Hamilton or Middle Devonian by Sir Wm. Dawson and apparently the development of the Devonian flora was more advanced or more varied and abundant in that region.

A similar story may be told of the overlying Genesee, Portage and Catskill. Dadoxylon (*clarki*) continues through the Genesee and Sporangites abounds. The more sandy Portage and Chemung are crowded in many places with plant-rags and other obscure relics of vegetation. An Asteropteris, *Lepidodendron chemungense*, the so-called *Sigillaria vanuxemi*, a stump of a tree-fern (*Caulopteris lockwoodi*), an Archæopteris or two, with a Spirophyton, are almost all the distinguishable forms yet described.

Nor is the Catskill more productive, though some species occur there in finer condition. The quarries at Meshoppen, Pennsylvania, have yielded to Mr. Lacoe excellent specimens of *Archaeopteris* (Cyclopteris) hibernica, with Rhaciopteris, and more lately, the magnificent *Dictyocordaites* of Dawson. The little Sigillaria (*Sigillaria simplicitas*) with its uncouth specific name, may mark the beginning of that stately genus.

IX. THE CLADODONT SHARKS OF OHIO.

The genus Cladodus has long figured in palæontology, in consequence of the great abundance of the peculiar teeth to which the name was originally given, and which were the only parts of the fish of which we had till lately any knowledge. Consisting of a medial cusp standing on a straight edge of a wide, flat, semi-elliptical base, with one or more lateral denticles on each side, they formed an easily recognized and unique type of fossil and many species have been described both here and in Europe indicating beyond doubt the existence of elasmobranch fishes in considerable force in the palæozoic seas.

These fossils are found in greatest quantity in the lower Carboniferous strata, especially in the Mountain limestone of Europe and in the equivalent beds of the southwestern states, and they have been considered specially characteristic of that horizon. Older rocks have, however, contributed a few, and the cladodont type has been known for years in the Devonian of North America. But the specimens are scanty in comparison with those of the later limestones.

Reference to our table of the vertebrate fauna of the Appalachian gulf will show that at least a single specimen, *Machaeracanthus major*, has been found in the Corniferous limestone of Ohio. It is represented by a few spines only, and with a few other doubtful fossils, represents all the present knowledge of the elasmobranch fauna of the time.

But the family was of earlier origin than the oldest Devonian rocks, as is sufficiently evident from the size and strength of the specimens. There is direct proof of this inference in the occurrence of elasmobranch fossils (shagreen) in the Ludlow limestones of England—Spagodus and Thelodus But during the interval little is known of the group or their history in Europe and in America. Should the Onchus described by myself from Pennsylvania prove to be elasmobranch, this will carry back the history of the family to a much more remote date, and show that sharks were among the first vertebrates to appear in the waters of the planet.

The Corniferous-Hamilton (Hamilton) is somewhat richer in remains of elasmobranchs. But even here they are not abundant. Oracanthus, with four species described by Newberry from this horizon, must be canceled. This author writes in the monograph: (p. 33):

> In a paper published some years since in the Bulletin of the National Institute at Washington, I described a number of fish remains obtained at Delaware, Ohio, by the late Dr. Mann. Among these three species of Oracanthus were described, viz., *O. fragilis*, *O. granulatus* and *O. abbreviatus*, all of which I now believe to be phases of the varied scutes of Acantholepis.

There remain therefore two species of Machæracanthus, a doubtful Psammodus, the enigmatical Cyrtacanthus and two species of Ctenacanthus to represent the Appalachian elasmobranch fauna of the Corniferous-Hamilton, enough to carry it through the period, but not enough to indicate abundance or predominance. The record of the eastern Hamilton is yet

more meagre, as the tables of the Devonian vertebrates will show.

In the overlying black shale, Huron or Genesee-Portage, the elasmobranch history is again broken, the solitary *Goniodus hertzeri* of Ohio alone representing it there.

The same break continues through the Erie shale (Chemung) a Cladodus (*C. carinatus*) from Warren, Pennsylvania —the earliest known cladodont—being the sole member of the elasmobranch class thus far recorded.

Until within the past few years the same barrenness was believed to characterize the next Ohio stratum, the Cleveland shale. Before the appearance of Dr. Newberry's Monograph, a few fossils had come to light which indicated the latent treasures of this unpromising horizon. Two or three spines of Ctenacanthus, a few cladodont teeth and one or two other species (see table) had been reported and were described in that work. Besides these, and after their discovery, a yet richer field was opened, when it was found that some of the great concretions of the shale contained not merely detached spines and teeth, but casts of entire fishes. Of these, one found by Mr. Fyler was figured and named *Cladodus kepleri* and the other found by Dr. W. Clark of Berea, was figured without description under the name of *C. fyleri.*

Others have since been discovered—a few by Mr. Kepler—but by far the greater number by Dr. Clark, who has by his industry, skill and perseverence made this field especially his own. His present collection, it is hardly necessary to say, stands unrivalled in the world for Devonian elasmobranchs; for nowhere else can be seen elasmobranch fossils of any age in so great numbers and in such perfection.

Besides the above mentioned specimens, a single imperfect fossil found near Glasgow, Scotland and described by Dr. Traquair in the Geological Magazine for 1888, is the only other known contribution to our knowledge of the external form and structure of the palæozoic elasmobranchs. His specimen appears also to differ considerably from those found in Ohio and it is not at present easy to reconcile the descriptions.*

* So rarely have any fossils of the kind been found that A. S. WOODWARD could write in his "Catalogue" (p. 11): "The only skeletons of Carboniferous fishes worthy of note are those of Sphenacanthus, Chondrenchelys and Cladodus from the Lower Carboniferous of Scotland. Cladodus from the Erie (rather the Cleveland) shale of Ohio and Pleuracanthus from the middle Coal Measures of France."

By the use of Dr. Clark's collection and a careful comparison of the specimens the writer has been able to define more or less completely, several species of Cladodus, a detailed account of which will be found beyond.

Most of the fossils found by Dr. Clark and Mr. Kepler are obviously of the cladodont type of dentition. They vary however, in details and especially in external form. Some of them differ considerably from either of the forms described by Dr. Newberry and it is uncertain if full knowledge when attainable will allow the retention of all the species in the old genus Cladodus. Indeed, even on the evidence of the dentition, the writer has found it desirable to separate two of them under a distinctive name—*Monocladodus*. But so long as the peculiar dentition, as originally defined by Agassiz, is the only limit, it seems unadvisable to multiply generic terms. Descriptions are at present so meagre, with the exception of those of the specimens from the Cleveland shale, that it is not possible to determine whether or not the species on both sides of the Atlantic are congeneric.

Leaving this question for the decision of the future, the fossils of Dr. Clark still enable us to lay down the following data regarding the genus Cladodus.

Cladodus, *Agassiz.*

Fish, so far as known, of moderate or large size, varying from two or three feet up to fifteen or twenty feet in length. Body slender, elongated, the greatest breadth being just behind the pectoral fins and tapering off slowly toward the tail.

Head about one-eighth or one-sixth of the total length, sometimes widening regularly from the snout to the front edge of the pectoral fins and, at others, attaining its greatest breadth at or near the hinder end of the jaws and then narrowing again a little to the fins.

Snout blunt when seen from below; (no lateral view is known, but it was probably more acute) showing large olfactory cavities; eyes large, lateral and very near the front (anterior) part, surrounded with a ring of small orbital plates often well preserved.

Mouth nearly terminal, mandibles straight, maxillaries nearly straight. Both are set with ten or more files of cladodont teeth on each side having from seven to ten teeth in every file or about 400 in all.

In some species, if not in all, there was a symphysial file of smaller teeth. The maxillaries apparently closed outside the mandibles, the two articulating with a well marked condyle, but no evidence of intermediate suspensorium is visible. Behind the condyle is a well marked backward projecting process. Along the upper edge of the mandible is a

recess for the reception of the teeth and the lower margin is strongly corrugated.

Pectoral fins, large and strong, with from 18 to 23 unjointed rays several of which run out on the fore-margin. Between those that deploy on the hind margin are secondary intermediate rays and between some of these occur even tertiary rays or raylets. The hind margin of the fin behind the tips of the rays and about half an inch in width is thin and only in some cases shows the presence of trichinosts.

Owing to the crushed condition of the basal cartilages it is not possible at present to make out the details of their arrangement or to express a confident opinion regarding the type of the fin. No axis such as would bespeak an archipterygial fin can be seen. If any such exist it lies within the line of the body and is therefore concealed by the skin; the fin is entirely uniserial, the fore-rays being stronger at base and widening to their tips, the midways being longest, widest in the middle and tapering outwardly where the secondaries are intercalated, the hind-rays rapidly diminishing in size and strength as their direction changes, till the hindmost are exceedingly weak, thin and soft. In general outline the fins are broadly triangular and are preserved in their fully expanded position, the hind edge being almost at right angles with the axis of the body.

The dorsal fins are but scantily displayed or not at all in consequence of the position of the fish, which in almost all cases lies belly-upward in the slab. They must have been inferior to the pectorals in strength and solidity, but few details are at present attainable.

The ventrals are also small and thin-rayed; though in somewhat better position than the dorsals, they have left but faint impressions of their form and size. They were broadly triangular, the basal or longest side being attached to the body. They contained apparently about ten rays the largest being medial but all thin and slender. They were placed behind the middle of the body.

The caudal fin is in a few cases partially preserved, but in most of the specimens is altogether wanting. The indications are that the ventral rays were strong and numerous, but beyond this few details can be given. Dr. Bashford Dean, of Columbia College, has figured what appears to be a better specimen in which he represents the notochord turning at almost a right angle with the line of the body and a row of cartilages on the dorsal surface filling the angle. If this prove correct and general it must be included in the generic definition.

The teeth while varying in detail are of the well known cladodont type, having usually a single median cusp and two lateral denticles sometimes half as high as the main point with frequently traces of other rudimentary ones beside them. The large cusp is generally slightly sigmoid, flat externally, with a slight median concavity in which lies the point of the following tooth and rounded internally with usually some slight striation near the base.*

* For the internal structure of the cladodont tooth see the *Proc. of the Am. Mic. Soc.*, 1894.

The dermal covering of the cladodonts consisted chiefly of shagreen of very minute pattern which is constantly and abundantly preserved. But on the ventral surface the skin is covered with fine, thin, spirally arranged scales strongly suggesting and simulating the armour of a tile-scaled ganoid.

Behind the ventral fins is a remarkable organ, if such it can be called, consisting of a flap or fold of the skin extending horizontally on each side of the body just in front of the caudal fin. It is semicircular, attached by the straight side to the body. It contains no rays, but is entirely composed of soft membranous tissue. Its presence gives to the hind end of the body viewed from above or below a most peculiar appearance. The sharp termination of the body ends in a point and together with the folds just described presents the form of a shovel. From the side the full outline of the caudal fin is seen and merely the thin edge of these fin-folds is visible.

The peculiar organ, last mentioned, may prove of no little interest in connection with certain theoretical views that are prevalent regarding the outline of the paired fins. The evolution of the azygous fins from the primæval and continuous marginal membrane seen yet in the bow-fin (*Amia calva*) and some other fishes and in the tadpoles may be considered an established doctrine however difficult it may at present be to account for the gradual concentration of fin-development at a few points in our recent fishes and to understand the fusion of the basals and their removal over a great part of the original line. But the parallel doctrine of the evolution of the paired fins—the archetypes of the four limbs of the higher vertebrates—from a supposed similar but horizontal continuous fold does not at present rest on an equally secure basis. If it is true, then changes have occurred in these more profound than any of which we have evidence in the case of the former (azygous) organs. And the greater amount of supposition required in the case of the lateral fin-fold in consequence of the absence or scarcity of intermediate forms is not to be lightly estimated. From this point of view therefore, it may be exceedingly interesting to find what may prove to be an ancient relic of such a primævel lateral fin in these Devonian elasmobranchs. If such an archetypal fold extended from the pectoral to the ventral fins it may well have extended farther to the place of these post-ventrals, if we may so call them, and then have run into the caudal and fused with the dorso-ventral fold, thus encompassing the body laterally as the other encompassed it vertically.

The absence of rays from these post-ventral fins may be regarded as an evidence of arrested development or of retrogression and may stand with the occurrence of a similar structure in the second dorsal or adipose fin seen in some of the Salmonidæ.

It may be rank heterodoxy to even hint at the existence of a third pair of limbs in a vertebrate animal. But on the above view there is nothing monstrous or incongruous about it. It is anomalous, judged from the existing creation, but so was the pineal eye when first mooted; yet it is an accepted fact in anatomy and explains some structures that were previously enigmatical. Considering how little we yet know of the forms of palæozoic vertebrate life it is far from improbable that other indications of this curious organ may yet come to light: but whether the solution above suggested is correct or incorrect, the fact is certain and awaits explanation that these Devonian cladodonts possessed this singular external appendage.

In regard to the armour of the cladodonts the testimony of Dr. Clark's collection is decisively in favor of the view that they were spineless. Not a single specimen shows any indication of any such armament. The pectorals are absolutely clear on this point. The ventrals are small and seemingly altogether soft and no signs of any hard or bony spines are visible on or near them. The dorsals are not known in a satisfactory condition, but so far as it goes their evidence is altogether negative and it is scarcely possible that any organ so thick and strong as an ichthyodorulite could have existed on them without leaving some trace of its presence on the fossil. There is, however, just a possibility lurking in here of the presence of weapons as yet concealed. It is, however, of the slenderest kind as would be admitted by any palæontologist, who examined the fossils themselves.

If then, all cladodonts were spineless sharks, it must follow that the wearers of Ctenacanthus and Machaeracanthus are still unknown.

The following is a summary of the species of cladodonts that have been described from the Cleveland shale, exclusive of those based on isolated teeth.

Cladodus kepleri Nby.

Length about 33 inches with the greatest breadth about 4 to 5 inches. Head bluntly rounded in front.

Pectoral fins with about 18 strong rays, two or three inches wide at the base, front edge about 6 to 7 inches behind the snout.

Teeth with a single denticle on each side of the main cusp and about one-fourth of its height, main cusp striate. See AM. GEOLOGIST, 1893, p. 326.

Cladodus fyleri Nby.

This species was merely named and figured by Dr. Newberry without description and it is very doubtful if it can be identified with certainty. No characters are given or ascertainable and the strong spine represented on the plate XLVI is almost certainly an error.

Cladodus clarki Claypole.

This is the best known species of the genus and a full description may be found in the AMERICAN GEOLOGIST for Jan., 1895. The leading points are as follows:

Length of fish about 45 inches. Breadth about 7 inches. Pectoral fins 6 inches long by 4 to 5 in width at base, situated about 11 inches behind the snout. Rays about 18, strong.

Teeth with a single median cusp and one denticle on each side of it about one-half of its length. Main cusp very lightly striate.

Skin on lower side of neck transversely wrinkled. This is probably a generic character.

Hinder portion of fish unrecognized.

In the abdomen of the first specimen found lay a large coprolite showing a spiral line indicating the presence of an intestinal fold—the so-called spiral valve of the shark.

Cladodus sinuatus Claypole.

Nothing can be added to the short description given in the AM. GEOLOGIST for May, 1903. The fish was smaller than any of the preceding species, not exceeding 30 inches in length and the fin-rays are thinner. As the teeth are not yet known the reference to Cladodus is provisional though almost certain. The species cannot yet be fully defined.

Cladodus rivi-petrosi Claypole.

The smallest known of the cladodont sharks of the shale, not exceeding 24 inches in length. The teeth show two lateral denticles on each side of the median cusp. At the least two different forms occur in the mouth of the single specimen known.

MONOCLADODUS, Claypole.

Several specimens in Dr. Clark's collection have been separated from Cladodus by the writer in consequence of the lack of the essential cladodont character—the denticles. The teeth, many of which have been exposed by the discoverer, show only the single median cusp which is long and of the usual cladodont form. To this genus are referred two of Dr. Clark's species as follows:—

Moncladodus clarki Claypole.—A fish about 63 inches long by 8 inches in greatest width between the pectoral fins.

Pectoral fins very large and strong, 8 inches long by 5½ in greatest width at base. They expand 22 inches from tip to tip, the fore margin is 13½ inches behind the tip of the snout.

The teeth are as in the generic description on a somewhat forking base, they are slightly striate.

Monocladodus pinnatus Claypole.*

This was a somewhat larger fish than the preceding species, measuring from tip to tip of the pectoral fins 24 inches. In general so far as is yet known the species differs little from the preceding, but its peculiar character lies in the great strength of the ventral fins which in all the previously mentioned forms were too weak to be distinctly marked in the fossil. Here they nearly equal the pectorals in strength though not in size and contain 12 strong bony rays.

Further details regarding this and other fossils from the same shale may be found in the pages of the AMERICAN GEOLOGIST for the years 1893, 1894, and 1895.

It is scarcely necessary to point out the fact that the presence of these sharks in the waters of the Appalachian gulf implies the presence of other fishes suitable for their food. This condition could hardly have been fulfilled by the great placoderms, Dinichthys, etc. In the stomach of one of Dr. Clark's specimens lies the half digested and macerated relics of a small Callignathus whose jaws are yet distinguishable. Other similar indications may be seen on some of the other specimens.

The great armour-plated fishes have passed away and have left but few and small representatives of their family in our present seas. But the smaller and unarmed, but active sharks are still abundant and are in many places the dominant fishes of the ocean. It may not be out of place to ask, Why is this so?

Nature probably had her time of experiment with armour-plating. She loaded bony protection upon these Devonian fishes until the limit of possibility was almost or quite attained. In some specimens of Dinichthys the supraoccipital bone is 3 inches thick. Secured thus against most of their enemies, these ponderous creatures must have been slow of motion. It is also probable that their hinder parts were unprotected. No trace has been found of any covering. Possibly in spite of their enormous size and weighty plating they were open to attack by their enemies from behind and could not escape by flight or turn and destroy their small but nimble assailants, whose agility rendered them formidable for attack and safe in retreat.

Speed—nervous activity—we have reason to believe was the determinant element in the solution of the problem of survival in the Devonian seas. The great placoderms like the heavy-armoured ironclads of our own day, were unable to cope with their more rapid foes and now as then the race may yet be to the swift, if the battle is not to the strong.

(*Concluded.*)

THE LOESS AND THE LANSING MAN.

By B. SHIMEK, Iowa City, Iowa.

The discovery of certain human remains near Lansing, Kansas, has provoked much discussion* which reveals a difference of opinion as to the value of the discovery. The writer has nothing to contribute directly to the facts concerning the Lansing remains, as his knowledge of them and their environment was gained at second hand. But an effort has been made to correlate the Lansing skeletons with the formation of a supposed loess horizon, † and the theory of the glacio-fluviatile origin of the loess has been resurrected to form the basis of an estimate of their age. It is to this that the writer desires to give attention.

Notwithstanding the fact that many trained geologists have in recent years been engaged in field work in the loess-covered regions of the Mississippi valley, no material facts have been added in a dozen years past to the support of the fluviatile theory, which was formerly generally maintained in this country in various modified forms. The recent arguments in its support are not based on additional observations and field investigations, but are specifically founded‡ upon the great works of Chamberlin and Salisbury on "The Driftless Area of the Mississippi Valley," published in 1885, and that of McGee on "The

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*S. W. WILLISTON, *Science*, vol. xvi, pp. 195-6, Aug. 1, 1902. WARREN UPHAM, *Science*, vol. XVI, pp. 355-6, Aug. 29, 1902; AM. GEOLOGIST, vol. XXX, pp. 135-150, Sept., 1902. N. H. WINCHELL, AM. GEOLOGIST, vol. XXX, pp. 189-194; Sept., 1902. T. C. CHAMBERLIN, S. CALVIN, and R. D. SALISBURY, *Jour. of Geol.*, vol. X., pp. 745, et seq., Nov., 1902. WARREN UPHAM, AM. GEOL., vol. XXXI, pp. 25-34, Jan., 1903. N. H. WINCHELL, *Bull. Geol. Soc. of Am.*, vol. 14 pp. 133-152, Apr., 1903; AM. GEOL, vol. xxxi, pp. 263-308, May, 1903, etc.

†WARREN UPHAM, *Science*, l. c.; AM. GEOL., vol. xxx, p. 143, etc.; vol. xxxi, pp. 25-34. N. H. WINCHELL, *Bull. Geol. Soc. of Am.*, vol. xiv, p. 141; AM. GEOL., vol. xxxi, p. 268, etc., May, 1903.

‡ See AMER. GEOL., vol xxxi, pp. 26-27; 268; 278; etc.

Pleistocene History of Northeastern Iowa," published in 1891.

The cautious, conservative statements of Chamberlin and Salisbury scarcely warrant the declaration that they "leave no doubt" as to the fluviatile origin of the greater part of the loess. Furthermore, at least one of the authors, Dr. Chamberlin, has materially modified his views concerning the loess since the publication of the work cited.

The splendid work of McGee, like that of Chamberlin and Salisbury a classic in glacial literature, had for its purpose the presentation of fundamental facts and conclusions bearing on glacial phenomena. If we omit loess from the series of deposits discussed therein, the conclusions still remain of great value. It is a fact long established that the loess forms a mantle pretty uniformly covering the underlying deposits of drift, etc., especially in eastern Iowa, and that, therefore, the so-called "loess-topography" is really drift-topography. If the loess could all be removed, the underlying drift would present essentially (though not exactly, especially along the Missouri river) the topographic features of the present surface. The altitudes of the more broken regions would be relatively less, as the loess is usually thicker in hilly country. Whatever, then, is prominent or striking in the topography of the present surface, was at least approximately equally striking in the post-glacial surface before loess was deposited upon it, and many of the peculiarities in the structure and distribution of these underlying deposits were well elucidated by that author, and are in no wise affected by dissent with the inclusion of the loess.

In justice to professor McGee it should also be stated that he was misled by erroneous information concerning the fossils of the loess, for his inclusion of the loess among glacial or sub-glacial deposits was evidently due largely to this fact. Several species which are not only terrestrial, but frequent uplands, had been reported as aquatic or semi-aquatic; other species were incorrectly identified; and in still other cases conclusions concerning the mollusks were unwarranted by the facts.

Some of the earlier reports upon the fossils of the loess were inexcusable. Aughey's list of fossils from the loess of Nebraska* is impossible. No such series of shells was ever

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*See Hayden's U. S. Geol. Sur. of Colorado and adjacent territory, 1876, pp. 266-269; also a practical reprint in Sketches of Phys. Geog. and Geol. of Neb., 1880, pp. 287-290.

obtained in the loess. His method of identification as related by himself* is sufficient to condemn the list as unworthy of serious notice. This list contains a large number of southern fluviatile mollusks, and the author states positively that "freshwater shells are quite abundant at some horizons." He also states that many of his specimens fell to pieces, and consequently he had no specimens to show! It was the writer's privilege to examine a remnant of professor Aughey's collection while at Lincoln in 1889-1890, and he found a small set of very ordinary loess fossils of terrestrial species. It is remarkable that the heavy-shelled *Viviparidae, Strepomatidae* and *Unionidae* mentioned in the list should have so disintegrated, while the delicate Pupae, and other fragile forms of the ordinary loess fauna should have been preserved!

Similar to this are the erroneous reports concerning the modern habits of the species of snails found in the loess.

Lyell speaks of the "amphibious genus *Succinea* † and of the abundance of freshwater and land-shells in the vicinity of Natchez, yet no aquatic shells have been discovered since.‡

Todd § refers to Succineas and Helicinas as semi aquatic.

Call, who alone of this list of writers made a pretense of special knowledge of conchology, reported *Helicina occulta* ‖ and *Pomatiopsis lapidaria* ¶ as aquatic, and *Succinea* as semi-aquatic!

But these forms are terrestrial and a mere tyro who would have taken the trouble to go to the field could have avoided such misstatements. Yet they have been accepted with others quite as unreliable and have been incorporated in geological papers to form the basis of important conclusions. Todd and Call both reported (l. c.) on the depauperated shells of the loess, and concluded that cold was responsible, and these conclusions were relied upon by McGee° who used them to sup-

*See "Sketches of Phys. Geog.," l. c.

†For discussions of Succinea see the writer's recent paper on The Loess of Natchez. AM. GEOL., vol. xxx, pp. 283-284.

‡In a recent private letter Dr. Hilgard, for many years a student of the loess in Mississippi, corroborates the writer's recent declaration (l. c. p. 282) that no aquatic species are as yet known from the loess of Natchez.

§Reprint from *Proc. A. A. A. S.*, vol xxvii, 1878, p. 6.

‖As *Helicina oculata*:—*Am. Nat.*, vol. xv, p. 586, 1881. This error concerning habit is copied by McGee, l.c. p. 461, in a statement at the close of a list of fossils quoted from the present writer. There was no warrant for such a statement in the article quoted.

¶*Am. Nat.* l.c., *Ark. Geol. Sur.* vol. ii, pp. 166, 167, 168, 1891.

The Löss and Associated Deposits of Des Moines, p. 16, 1882.

°See Löss and Associated Deposits of Des Moines, p. 23, et seq.

port this theory of the sub-glacial origin of the loess. Yet the living fauna of the loess-covered regions shows essentially the same depauperation. The comparisons which Call makes in the paper on the Des Moines loess are based in part, at least, upon measurements of eastern modern shells.*

Had the author taken recent shells from Iowa, especially from the prairie sections, he would have been left practically without support for his conclusions.†

The causes which produced a "depauperation" of some of the shells are in operation today in Iowa and adjacent territory, for practically all of the fossil cases may be duplicated in the modern fauna.

Another source of error of a more excusable nature in the reports on fossils is to be found in misconception of species and incorrect identification. For example, what was generally reported on *Vallonia pulchella* from the loess is *Vallonia gracilicosta,* a northwesterly upland species; under fossil *Succinea obliqua* were included two, possibly three species; *Carychium exiguum* (reported as semi-aquatic by Call, in paper on Des Moines loess, l. c. p. 16!) has not been found in the loess, the fossil species being *C. exile,* a decidedly upland species; the form commonly reported by earlier writers as *Pupa blandi* is *Bifidaria pentodon* (though *P. blandi* occurs in the loess), and possibly a *Vertigo;* and other instances might be cited showing that species were not clearly recognized by conchologists, and in consequence comparisons of fossil shells were sometimes made with recent shells of different species. Manifestly conclusions drawn from such comparisons are worthless.

Both Drs. Chamberlin and Salisbury, and professor McGee relied upon such information and were misled by it. The aquatic shells of the loess are relatively very few, and all of that type which inhabit small ponds. There is not a single well authenticated species of fluviatile mollusks known from clearly undisturbed loess in this country! And yet reference is constantly made to the few paltry pond snails, coupled with vague references to "semi-aquatic" forms, while the vastly

*The present writer, then a college student, made the drawings for the plate which illustrates that paper.

†For discussion of depauperation of shells by the present writer see: *Proc. Ia. Acad. of Sci.*, vol. iii, p. 85, 1896; vol. v, pp. 43-4, 1897; vol. vi, p. 101, 1899; *Jour. Geol.* vol. vii, pp. 126, 127, 1899.

greater number of truly terrestrial and upland species is made subordinate!

The writer thus refers to these details at some length to show that the supposed information upon which these eminent authors based their conclusions, at least in large part, was erroneous, and that consequently the conclusions themselves cannot be entirely correct. Mere reference to these conclusions, therefore, does not settle the case. Both the great works cited represent the results of pioneer efforts, and were not primarily concerned with the origin of loess, that question being largely incidental. With this prop removed there remains nothing but generalities for the support of the recent revival of the glacio-fluviatile theory.

In this connection the writer desires to refer at some length to certain statements made by professor Winchell* concerning the Unio which was found in the Lansing deposit. In order that there may be no misunderstanding concerning these statements they are here reproduced in full:

"In case the Unio were a true fossil, it would be, of itself, sufficient proof of the subaqueous deposition of the materials in which it lay. Land shells may form fossils in aqueous deposits, but never water shells in land deposits. It is, a priori, however, the strongest evidence of sub-aqueous origin of the loess in which it was found,....and the agreement which it has with obvious other features of the deposit serves to accumulate such a weight of testimony in the same direction that it requires the greatest hardihood to attempt to explain it on the hypothesis of land origin of the deposit."

The same author had previously† made the following statement:

"Many land forms may exist in an aquatic formation but the *existence of a single aquatic fossil species in the loess requires the presence of water.* Many have been identified by good authorities."

In the face of the foregoing statements it may be an exhibition of greatest hardihood to venture to still maintain the ground that the loess is of land origin, and that as evidence of the sub-aqueous origin of the loess the Lansing Unio is worth-

*Am. Geol., vol. xxxi, p. 282.
†*Bull. Geol. Soc. of Am.*, vol. 14, p. 145, Apr., 1903.

less, but regard for scientific truth makes the exhibition imperative.

Granting for the sake of argument that the Lansing deposit is true loess,—though the difference of opinion among those who have examined it makes this extremely doubtful,—if it can be shown that aquatic shells of the fluviatile types, or at least, types of aquatic shells other than such as inhabit insignificant pools and ponds, are extremely rare, if occurring at all in the loess; and if it can be demonstrated that fresh-water shells are sometimes transported to higher points by agencies other than floods; then the dogmatic statements quoted above fall of their own weight.

The present writer has repeatedly called attention to the absence of fluviatile shells from the loess,* giving in each case specific detailed lists. He here takes the liberty to state that he has searched for loess fossils north and south for nearly a quarter of a century; that starting out as a believer in the water theory of loess deposition he diligently sought aquatic forms, and for many years would have welcomed them with the same avidity with which the advocates of the theory have pounced upon the Lansing Unio; that after the conviction was forced upon him, against his earlier views, that the loess was not of aqueous origin, he equally carefully collected and preserved all fossil shells of aquatic species;—and the result of these efforts has been that no fluviatile shells were found in undoubted loess, the aquatic species, comparatively insignificant in number, being all such as are known to conchologists as pond-shells. The same species occur today all over the loess territory in small bodies of water,—creeks and ponds,—which may remain dry during many weeks, or even months, each year. This negative evidence is not conclusive excepting as to one point, namely: that fluviatile shells are extremely rare, if not wholly wanting, in the loess.† That modern fluviatile shells may occasionally be transported to higher grounds without floods has also been shown by the writer.‡

***Proc. Iowa Acad. Sci.*, vol. v, pp. 32-45, 1898; vol. vi, pp. 98-113, 1899; *Jour. Geol.*, vol. vii, March, 1899; *Bull. Lab. Nat. Hist. State Univ. of Iowa*, vol. v, pp. 195-216, 1901, (reprint AM. GEOL., Dec., 1901); AM. GEOL., vol. xxx, pp. 280-298, 1902.

†The writer has collected a few fluviatile Unios at Sioux City and Hamburg, Iowa, in a loess-like deposit, probably washed loess, lying far below the adjacent typical bluff loess, where high water might have reached it. Dr. Bain reports Unios from a deposit in Plymouth county, Iowa, which he does not consider true loess. See *Iowa Geol. Sur.*, vol. viii, p. 340.

‡*Proc. Ia. Acad. Sci.*, vol. v, p. 37, 1898.

The following specific references may be added: Several years ago the writer saw a crow picking at a small fresh Unio on a timbered riverbluff not less than fifty feet above the river, near the state quarries north of Iowa City. The Unio was on the ground and was probably brought up from the river, then at a low stage, by the crow.

About twenty-two years ago, while engaged in zoological work as a college student, the writer shot a solitary sandpiper one of the toes of which was clasped by a living *Spaerium transversum,* a small aquatic bivalve. This might easily have been dropped on high ground in one of the longer flights of the bird.

Three years ago the writer found a medium-sized shell of *Campeloma subsolidum* on a rocky, almost inaccessible slope below the University observatory at Iowa City, at a point not less than forty feet above the river. The shell, though dead, still retained its epidermis. *Campeloma subsolidum* lives abundantly in the river, and at low water is often exposed on the sand-bars near this bluff, from which blue-jays or other birds could have easily carried it for food while it still contained the soft parts.

In view of these facts, and of the numerous possibilities suggested by them, it is extremely rash to say that "the existence of a single aquatic fossil species in the loess requires the presence of water," for such shells as those which have been mentioned could be covered by dust, and in time become fossils in a land-deposit. Manifestly, this "strongest evidence of the subaqueous origin of the loess" is very weak and unsatisfactory.

The advocates of the aqueous theory can find little solace in the fossils of the loess, and without them their case has but little tangible support.

In the papers cited it is assumed:

1. That there "were widely extended depressions of our vast glacial area,"—and that in these depressions loess was deposited in water, and by subsequent elevation was brought to the present level.

2. That the streams flowed in ice-walled channels, and the swollen rivers were uplifted on them to hights of 150 to 250 feet above their present beds, and that the floods of these rivers deposited loess in successive layers.

3. That the valleys were filled with loess and subsequently eroded, so that the loess now represents only a remnant which remained after extensive erosion.

4. That the loess was deposited wholly (or at least in greater part) during the Iowan stage of glaciation.

5. Since the evidence of aeolian origin cannot be wholly set aside, it is assumed that there is an "upland loess" of aeolian origin, but that a "valley loess" owes its origin to fluviatile agencies.

6. Professor Winchell, (l. c.) especially maintains that there is no satisfactory distinction between the loess and the drift.

The first of these assumptions has been made repeatedly simply to meet an emergency. There is no direct evidence that such movements have taken place in more recent time. There is evidence in other parts of the world that slight movements do take place, but nothing has thus far been produced in the area under discussion, other than the assumption which is essential to a theory of the formation of the loess. Such depression would result in the formation of large bodies of water. Where are the shore-lines or other evidences of the existence of such bodies of water?

The second assumption is based on McGee's explanation of the formation of the river-valleys along the highest ridges, which, while applying to the underlying drift cannot be extended to the loess. The ice-walled channels would call for climatic conditions which are impossible in view of the fossil fauna of the loess, and the vegetation which was necessary to maintain it. To show the possibility of the existence of plants, etc., even in close proximity to perennial ice, attention has been called to the fact that in alpine regions trees and other plants sometimes grow on masses of earth which were carried over glaciers by land slide. The conditions in the glacier-covered Mississippi valley, however, must have been entirely different. If the glacial mass was so thin and in a climate so warm that it melted away during each season to expose the necessary land surfaces, then there could have been no steady advance of the ice-mass by which enormous quantities of material were carried hundreds of miles from the northern ledges of rock to which they can be traced. If on the other hand the greater

part of the ice-mass persisted year after year the climate must have been such that snails of the species which we find in the loess, and the plants which they required for food, could not have existed. Glaciers in mountainous regions are not to be compared with such a mass, and do not necessarily indicate a cold climate. A difference of a few feet in altitude, or the protection offered by a sheltered valley or ravine, may be sufficient to preserve a small glacier even in a climate in which plants may grow abundantly. The writer has seen a profuse mass of summer flowering plants growing against the side of an ice-house within two feet of a great mass of ice! But imagine plants and snails growing in such a region as is pictured by McGee in pl. LX, p. 575 of his great report!

The third assumption is untenable. It would be remarkable indeed if over the greater part of the loess-covered region the assumed loess-silt originally filling the valleys should have been removed with such nice exactness that a practically uniform thickness remains covering the irregularities of the drift surface beneath, on sides and tops of slopes, even on opposite sides of the same ridge, and hence in different drainage areas! Moreover, loess frequently shows a lamination *parallel with the present surface*, and hence not often horizontal. This is especially noticeable in northeastern Iowa, where the loess-sheet thins out, as for example in most of the exposures north of Decorah.

The fourth assumption, that loess is of the Iowan age, has a certain amount of foundation in fact, but is unwarranted in the extent of its attempted application. It is based on the investigations and reports of the geologists of the Iowa Geological Survey,* who investigated the loess in some of the counties along the border of the Iowan drift. All the Iowa references cited have special reference to this restricted area, and in most cases the authors specifically so state. Bain (l. c. p. 461) says: "The loess found in the region has been referred to the Iowan since it is believed to be in this region the equivalent of the Iowan drift farther north, and now in part buried under the

*Calvin, S., *Ia. Geol. Sur.*, vol. vii, p. 89, 1897; vol. viii, pp. 173-4, 216, 1898; *Bull. Geol. Soc. of Am.*, vol. x, p. 118, 1899. Bain, H. Foster, *Ia., Geol. Sur.*, vol. v, pp. 155-6, 1896; vol. vi, pp. 461-3, 1897. Beyer, S W., *Ia. Geol. Sur.*, vol. vii, p. 236, 1897; vol. x, p. 281, 1900. Leverett, Frank, of the U. S. Geol. Survey, also tentatively refers a part of the loess of Illinois to the Iowan. See *U. S. Geol. Sur.*, vol. xxxviii, p. 153, 1899.

Wisconsin. It is believed that loess of widely different ages occurs in the Mississippi valley." Calvin (l. c. p. 118) says: "Loess, or a product resembling loess, was developed in connection with more than one drift sheet, and it is possible that the Iowan loess blends into loess-like deposits of different age in some portions of the extra-marginal territory."

There is at present no warrant whatever for the reference of all loess, and especially that of the Missouri river, to the Iowan age, and even if it be possible to show that the Lansing skeletons rested in undisturbed loess this will not prove that they belong to the Iowan.

A thin layer of loess is found over a part of the Iowan and the Wisconsin* and no connection has yet been established between the Iowan and the loess of the Missouri and Big Sioux river regions. Indeed, Bain refers to the northwestern loess in the following words:†

"It is known, however, that loess in northwestern Iowa probably belongs to more than one geological epoch, and professor Macbride's observations in Humboldt county make it conclusive that the Iowan did not cover the region immediately north of Carroll county as has heretofore been believed. The correlation of this loess in Carroll county with the Iowan drift is accordingly open to considerable doubt."

If these words apply to loess comparatively near to the Iowan border, what shall be said of the great mass of loess along the Missouri and lower Mississippi rivers, covering an area vastly greater than the known Iowan border region, and between which and the Iowan no connection whatever has yet been established?

It is the writer's opinion that the accumulation of a comparatively large amount of loess along the border of the Iowan drift is explained by the fact that this border follows the larger streams of this part of the state, the Iowa, Cedar, Wapsipinicon, Maquoketa and Turkey. The deposit is thickest in the southern portions of the area, where the river valleys are broad, and where winds could easily gather up quantities of dust from the sand and mud bars exposed at low water. In any case no

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*SHIMEK, B., *Proc. Ia. Acad. Sci.*, vol. iv, pp. 68-72, 1898. BAIN, H F., *Ia. Geol Sur.*, vol. ix, p. 91, 1899. CALVIN, S., *Bull. Geol. Soc. of Am.*, vol. x, p. 119, 1899; *Iowa Geol. Sur.*, vol. xiii, pp. 328-9, 1903.

†*Ia. Geol. Sur.*, vol. ix, p. 92, 1899.

proof has yet been furnished that the Lansing loess is contemporaneous with the Iowan drift.

The attempt which Upham makes* to divide the loess into an aeolian "upland loess" and an aqueous "valley loess," which is practically a repetition of Hershey's effort,† is not successful. He says: "...the winds...blew away much of the fine loess dust and spread it far and wide over the interfluvial higher lands." Unfortunately the interfluvial lands are often lower than the loess ridges along the streams. As the loess recedes from the streams it usually becomes thinner and its materials finer, both of which facts can probably be accounted for by the greater distance from the source of supply of the material,—the bars of the streams. He further states that "In these great areas of eolian loess only terrestrial shells are found." As a matter of fact most of the loess remote from streams (the "upland loess") is non-fossiliferous. However, where fossils do occur they are chiefly, or wholly, terrestrial. But so are the fossils from Natchez and Council Bluffs; so are the fossils of by far the greater part of the loess wherever it is found. No line of demarkation, vertical or horizontal, can be drawn between two such divisions of the loess. There certainly is nothing known at present to indicate genetic differences.

Hershey (l. c.) attempted to separate the upland non-fossiliferous loess from that which is fossiliferous, but the presence or absence of fossils does not prove difference in origin. This point has already been sufficiently discussed by the writer.‡ Neither differences in altitude nor differences in fossils offer satisfactory characters for a division of the loess, for both fail when subjected to the only reliable test,—namely, application in the field.

Differences in composition and texture may frequently be observed in the loess. It is evident that not all loess is of the same age as measured with reference to the several drift sheets which have extended southward into the latitude of Iowa. The deposition of loess has continued through all the intervals of the ice. In the more northerly regions (i.e. Iowa, etc.) over which the several ice-sheets passed, there were more or less

*Am. Geol., l. c., p. 29.

†See Am. Geol., vol. xxv, pp. 369-374. 1900.

‡The Distribution of Loess Fossils, *Proc. Ia. Acad. Sci*, vol. vi, pp. 98-103, 1899; *Jour. of Geol.*, vol. vii, March, 1899.

sharply defined differences between different portions of the loess. Such differences have been observed by Todd and other earlier observers. Tilton reported two loesses in Warren county,* and in Madison county, Iowa.† The present writer reported differentiation in the loess at Council Bluffs.‡ Calvin discovered two distinct beds of loess in Page county, Iowa.§ During the past summer professor Calvin found two superimposed loesses in sec. 20, Bluffton township, Winneshiek county, Iowa, the lower, evidently pre-Iowan, being bluish-gray, with very large iron-tubules and numerous lime-nodules, while the upper is yellow and homogeneous. The writer subsequently examined a similar exposure in sec. 3, Decorah township, and several were observed in other parts of the county. In these exposures the line separating the two loesses is distinct, and they evidently differ very much in age. Even more striking is the case of two loesses, both fossiliferous, discussed by Udden in Rock Island county, Illinois, and reported by Leverett,‖ for these are separated by more than 90 feet of drift and black soil. Loess is found upon the Wisconsin, the Iowan, the Illinoisan and the Kansan drift-sheets, and some of it is evidently pre-Iowan. Certainly all of it is not Iowan.

Southward, in the regions not reached by the later drift-sheets, including therefore the vicinity of Lansing, there were no such abrupt interruptions in the deposition of loess, and this continued to the present time, possibly in varying degree, through all the climatic changes which so materially modified the northern surfaces, but southward probably affected only the character of the vegetation. Thus a deposit of southerly loess might be the equivalent in age of several of the northern drift-periods, without showing lines of demarkation between the several periods, which in the south were more or less merged into one. With our present knowledge it is certainly impossible to correlate southern loess, or any part of it, with any particular drift-sheet.

The seventh proposition, that loess and drift intergrade, is emphasized by Winchell¶ for the purpose of showing that the

*Ia. Geol. Sur., vol. v, pp. 318-19.
†Proc. Ia. Acad. Sci., vol. iv, p. 49.
‡Proc. Ia. Acad. Sci., vol. vi, pp. 107-8: *Jour. of Geol.*, vol. vii, pp. 132-3, 1899.
§*Ia. Geol. Sur.*, vol. xi, pp. 444-5, 1901.
‖U. S. Geol. Sur., vol. xxxviii, p. 115; 1899.
¶*Bull Geol. Soc. of Am.*, vol. 14, pp. 141-2; Am. Geol., vol. xxxi, pp. 279-282.

loess was deposited under glacial conditions. To judge from his statement there is no clear distinction between the two deposits, yet the statement that loess can be "in most cases certainly identified by student and layman alike" is just as true as it was when McGee wrote it. It is true that at some points, especially along the border of the Iowan drift, sand is more or less mingled with the base of the loess and that usually the line between the loess and the drift is not absolutely sharp, but this is precisely what would be expected under the aeolian hypothesis. The recession of the glaciers left the surface covered with till, boulders and sand. Along the drift-borders, and especially along the streams near the Iowan border, there were ridges of overwashed sand presenting sand-dune conditions perhaps not unlike those which now prevail along the Missouri near Missouri Valley and Modale, Iowa, and Blair, Neb., or along the Platte river near Freemont, Neb. As soon as a vegetation, at first scant, gained a foothold dust was retained more or less, but for a time stronger winds, perhaps in drier seasons, would occasionally sweep sand over the plant-covered areas, and a mingling of sand of different degrees of fineness, and of dust was the result. As vegetation gained a better foothold over larger areas these incursions of sand became less frequent, and finally ceased. Such mingling of sand and fine soils may be observed today at the localities named, and fine illustrations may be seen along the road leading east from West Point, Neb., where sand and loess, evidently wind-blown, are interstratified in various ways. At one point along this road fossiliferous loess has been covered by wind-blown sand in comparatively recent years. That the fine sands at the base of the loess sometimes (though rarely) contain fossils is not inconsistent with the æolian hypothesis. The writer has found living *Succinea grosvenorii* in mingled sand and loess on top of the high ridge northwest of Hamburg, Iowa. Some of the dead shells, still somewhat fresh, were already partly covered with dust and sand. Some of the sand so transported by wind today is coarse and even contains small pebbles.

The "southern loess" discussed by McGee, whom Dr. Winchell quotes so extensively, is the loess of the Iowan border in Iowa, and this rests upon morainic sands,* which must have

*CALVIN, S., *Ia. Geol. Sur.*, vol. vii, pp. 88-9, 1897. BEYER, S. W., *Ia. Geol. Sur.*, vol. vii, p. 236, 1897; vol. x, p. 281, 1900.

presented ideal conditions for such mingling of sand and dust. It is here that his hybrid "drift-loess" was formed. There is no connection, as far as known, between this "drift-loess" and Calvin's "flooded valley deposits" which are referred to the "drift-loess" by Winchell.*

The occurrence of real till in loess, excepting where slipping may account for its presence, has not yet been demonstrated. Even Bain's example,† is not conclusive. He says that the exposure of till to which he refers is "about 150 feet above the river, and the till is above any similar deposit known to occur in this vicinity." Anyone who is familiar with the topography and altitudes of the part of Woodbury county referred to, will be very slow to make unquestioned application of Bain's careful statement concerning a point only 150 feet above the river. In any case the extreme rarity of such cases should lead to great caution. Loess and drift are not so intermingled as to warrant sweeping conclusions concerning genetic relationship.

The fineness and homogeneity of the loess, together with the presence of numerous terrestrial fossils which required abundant vegetation for their maintenance, are sufficient to show that the loess was not deposited by ice. If it is maintained that the loess was deposited by flooded streams after the ice receded, then it devolves upon the advocates of this theory to explain the following phenomena:

a. The region immediately adjacent to the larger streams in our loess-covered sections is the highest, as a rule, and has the thickest deposit of loess. There are no bluffs or elevations lying beyond, which could have formed the banks of the swollen streams. If there were great barriers southward which retained the vast volumes of water postulated by this supposition where are traces of them?

b. The loess is fine and comparatively homogeneous. The movement of such enormous volumes of water would certainly have resulted in the transportation of more coarse material.

c. The loess is usually of approximately uniform thickness on tops and slopes of hills, and is often laminated parallel to the surface. Under what conditions could flooded streams have produced this result? If it is assumed that the loess was deposited

*Am. Geol., l. c. p. 279.

†Cited by Winchell, Am. Geol., l. c. p. 281.

in enormous lakes, where are their shore-lines, and where were the land areas which produced the terrestrial mollusks?

d. The loess is more or less fossiliferous, especially where it is thickest, and where therefore the floods should have had greatest influence. The shells are, with slight exceptions, those of land snails which are not found, at least in large part, upon alluvial low lands adjacent to streams. Great floods covering such areas would render them wholly unfit for such plant life as these snails require. Presumably these floods would come in late spring and summer. How much advancement of plant and snail growth could be expected in the fall, winter and early spring?

In his recent article* Upham makes the remarkable statement that in "the summers of each year the floods pouring along the valleys from the ice melting and rains added little to the surface of the whole flood plain; but in autumn, winter, and spring, the diminished rivers flowed in comparatively narrow channels, probably permitting the main part of the flood plain to become more or less covered by grass and other vegetation, and to be inhabited by air-breathing mollusks."†

It is fair to presume that under the climatic conditions here assumed the winters were still long, and that much ice was formed each season. If the streams were flooded four months each year, as suggested, and much of the remainder of the year was winter, when did the grass and snails grow? And, furthermore, where do modern representatives of the loess species of molluscs live under such conditions?

If it is argued that the mass of loess was gradually accumulated by a succession of floods, which periodically receded sufficiently to expose land-surfaces, then it is necessary to consider movements of enormous volumes of water in comparatively short time, for the loess-covered regions are not in restricted depressions, and enormous floods would be required to cover them. In Iowa, for example, these floods would have covered the greater part of the state. The loess-topped hills at Iowa City are lower than the loess border near the Mississippi river, and the hill south of Carroll, about 275 miles west of Iowa City, and more than 600 feet higher,‡ and forming a part

*Am. Geol., l. c. p. 29.

†Substantially the same statement had been previously made by him in *Bull. Geol. Soc. of Am.*, vol. 5, p. 94.

‡See R. R. profiles, Iowa R. R. Commission, 1881.

of the great divide between the Mississippi and Missouri, is covered with fossiliferous loess! To periodically drain such an area sufficiently to leave land areas exposed for a sufficient length of time each year to enable a flora and a snail fauna to develop, would require currents so strong that much coarse material would be transported, and the loess would not be so uniformly fine in texture.

But the absurdity of the proposition that snails could grow under such conditions will appeal to everyone familiar with their rate of growth and their habits. It may be that those who have made the earth's surface in the loess-covered region conveniently move down and up through a vertical distance of 300-500 feet to accommodate their theories, may find it easy to conceive of a change in the habits of insignificant snails, or may not consider their testimony of much weight. But those who have studied these snails in the field know that many of them show a remarkable persistence in habits. Thus *Helicina occulta,* the most universally distributed loess fossil of the northern Mississippi drainage, lives in a few restricted and widely separate areas,* invariably upon high grounds in hilly country covered with abundant vegetation. *Succinea grosvenorii,* also common in the loess, habitually seeks dry and more or less elevated surfaces,—whether in Mississippi or Nebraska,—and, so far as the writer's experience goes, is never found on low alluvial bottom lands.

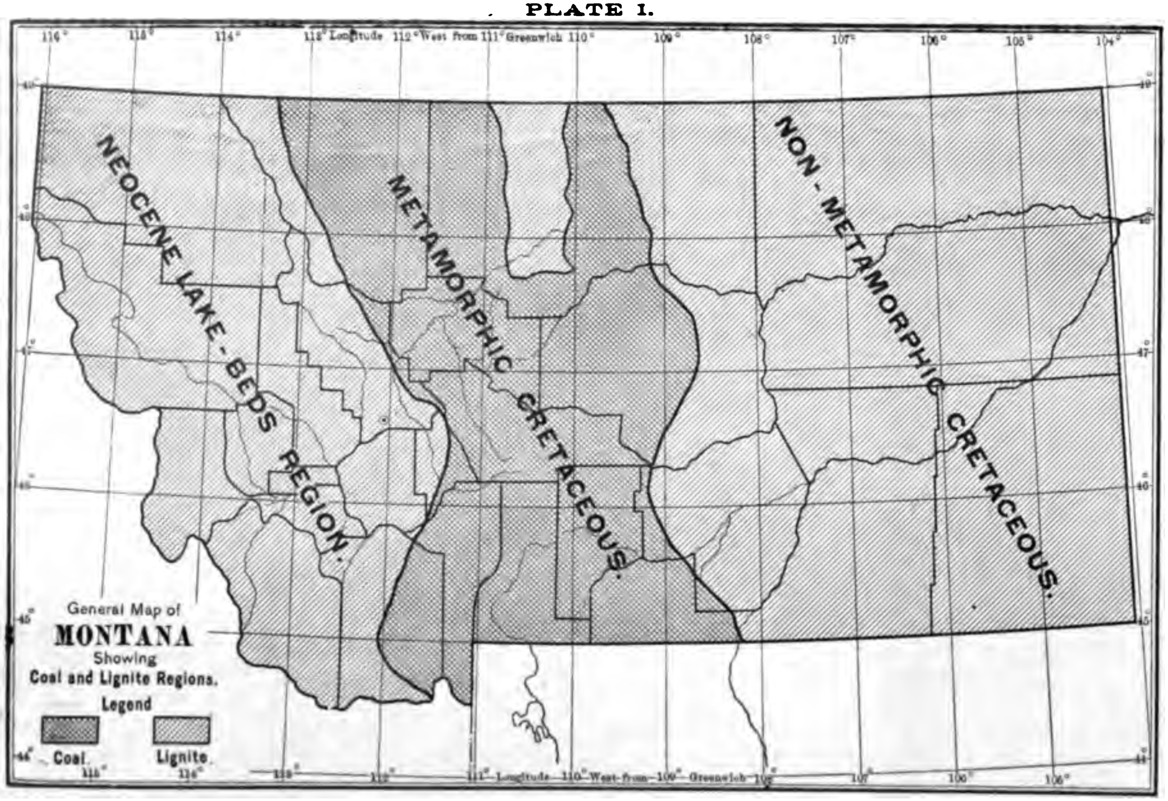
Such forms as *Vallonia gracilicosta, Strobilops virgo, Leucocheila fallax, Bifidaria holzingeri, B. curvidens, Cochlicopa lubrica, Vitrea indentata, Succinea avara, Pyramidula alternata,* and *P. perspectiva,* of our northern loess, and most of the species of the southern loess,† habitually frequent higher grounds, while all the species, without exception, which are found in the loess north or south, are living today upon high grounds which are not subject to overflow, though in some cases these species also extend to the lowlands.

The fauna of the loess is not such, species for species, as is found today on the alluvial bottom lands along our streams, and it is lacking in fluviatile forms. The significance of this fact must not be underestimated, and the value of such testi-

*At Iowa City, Eldora and Dubuque, and in Allamakee, Clayton, Howard, and Winneshiek counties in Iowa: Winona, Minn.: and isolated localities in Wisconsin, Pennsylvania, Virginia and Tennessee.

†See AM. GEOL., vol. xxx, p. 290, etc., 1902.

PLATE I.


NEOCENE LAKE-BEDS REGION.
METAMORPHIC CRETACEOUS.
NON-METAMORPHIC CRETACEOUS.
General Map of
MONTANA
Showing
Coal and Lignite Regions.
Legend
Coal.
Lignite.

mony must be placed far above merely supposed phenomena for the support of which there is no direct evidence, but which are necessary to sustain a theory. Fossil shells are not rare in the loess. They are as widely and as generally distributed in that deposit as their modern prototypes are upon the surface today.* The habits of these snails are known. They present a tangible, definite basis for conclusions, and their occurrence is wholly consistent with, and best explained by the æolian hypothesis of the origin of the loess. These fossils will continue to be the rock which will wreck the arguments of the advocates of the glacio-fluviatile and aqueous, theories, until an explanation of their presence in the loess, consistent with these theories and based upon observation and fact, can be presented.

SOME MONTANA COAL FIELDS.

By J. Perry Rowe, University of Montana, Missoula.

PLATES XXXI-XXXII.

In answer to many inquiries, both from a commercial and a scientific point of view, is taken this opportunity to give a general idea of the extent of the bituminous and semi-bituminous coal fields of Montana. The writer is preparing a bulletin on the Montana coal fields, and hopes within another year, to have statistics and measurements of beds from every coal county in the state.

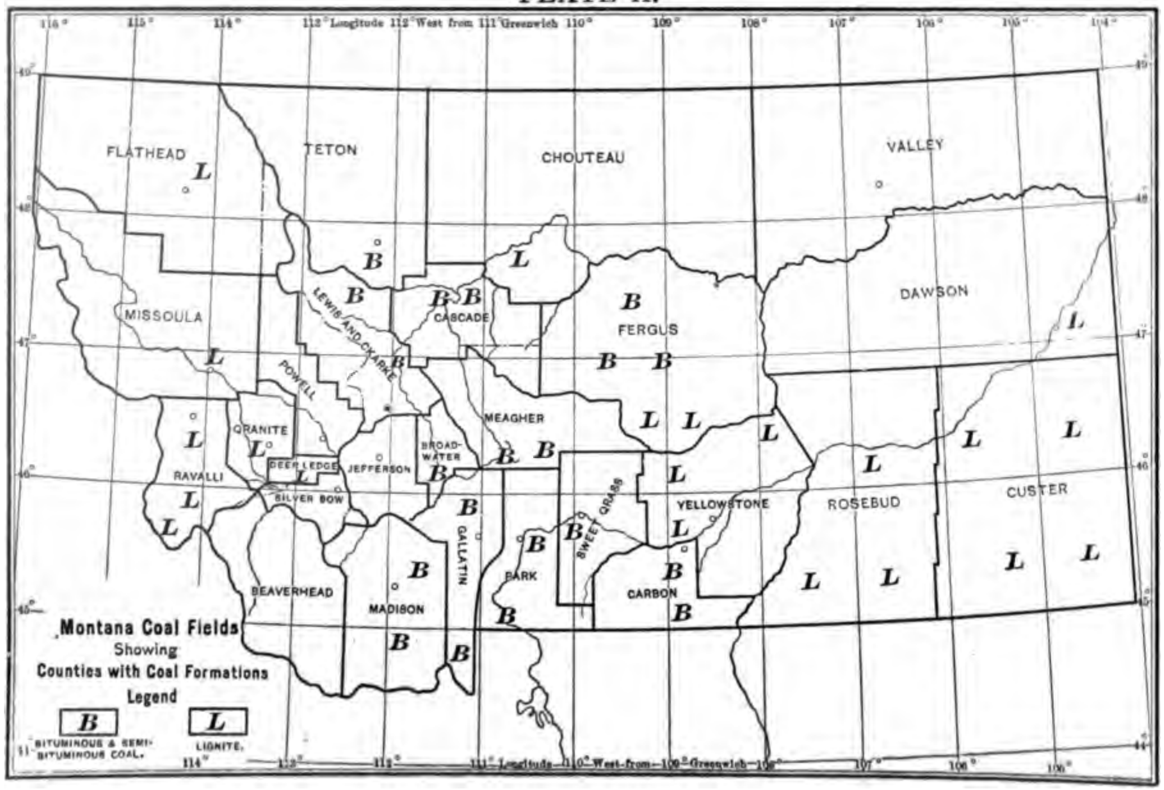
Montana is undoubtedly one of the richest states in coal and lignite in the union, although as yet these deposits have been but very little developed. There are less than two inhabitants for each square mile of its territory, so in the past there has been no necessity for a thorough investigation of its fuel resources.

All, or most of the bituminous and semi-bituminous coals found in Montana come from the Cretaceous period and usually from the upper part, or the Laramie formation; and are found east of the main divide of the Rocky mountains. The lignite is found both in the Cretaceous and later Neocene formations.

According to the map (Plate I) it may be seen that the Cretaceous formations cover a large area of the state, and that good

*See the writer's discussion of this subject: *Ia Acad. Sci.*, vol. v., pp. 14-15, 1898; vol. vi, pp. 98-113, 1899; etc.

PLATE II.


FLATHEAD
TETON
CHOUTEAU
VALLEY
MISSOULA
LEWIS AND CLARKE
CASCADE
FERGUS
DAWSON
POWELL
MEAGHER
GRANITE
BROAD-WATER
JEFFERSON
DEER LEDGE
RAVALLI
SILVER BOW
GALLATIN
SWEET GRASS
YELLOWSTONE
ROSEBUD
CUSTER
PARK
CARBON
BEAVERHEAD
MADISON
Montana Coal Fields
Showing
Counties with Coal Formations
Legend
BITUMINOUS & SEMI-BITUMINOUS COAL.
LIGNITE.

of these beds are found in the southeastern portion. The products of these deposits as yet have not been put upon the market to any great extent, being used only for local domestic purposes. This variety of coal is easily broken when first quarried, but becomes very friable or slacks and crumbles after a short exposure to the air. North Dakota has a large area of this kind of fuel and is making it into briquets and placing it on the market. Montana to some degree is profiting by this example; however, but very little lignite of this kind has ever been made or sold in the state.

The true or best bituminous coals are found in the less metamorphic Carboniferous and a small amount in the Permian. The poorer varieties of bituminous coal, usually non-coking, are found mostly in the Rocky mountain or metamorphic regions, and belong to the Jura-Trias and Cretaceous, while the lignite varieties belong to the non-metamorphic Cretaceous and Tertiary formations, and peat to the more recent. Thus, if coal prospectors in Montana and other western states would look up a few points on general geology, much time and money could be saved.

However, in highly metamorphic regions, the lignite is turned into semi-bituminous and bituminous coals, quite often into anthracite, and sometimes, when there has been an excess of change of strata the lignite is turned into graphite. This is shown to an admirable degree in the Rhode Island Carboniferous coal fields; the western Pennsylvania fields are all bituminous, because there has been but little change in the strata, while some of the eastern portions are anthracite, probably due to the orographic movements.

Montana coal fields are similar in this respect to the Pennsylvania fields. The eastern portion yields lignite, while the central mountainous metamorphic portion yields a semi-bituminous, and bituminous, and in one or two other localities a small amount of semi-anthracite coal. There is also one highly altered field that gives a little graphite. So far no true anthracite coal has been found in Montana.

The various counties in the state will now be taken up with a brief discussion on one or two of the chief deposits in each county (Plate II.).

Flathead County.

This county is located in the northwest corner of the state, with Canada bordering on the north, and Idaho on the west. It is crossed by the Great Northern railroad from east to west, and Kalispell is its county seat.

The coal beds in this county undoubtedly belong to the Cretaceous period and are quite extensive, and the coal is semi-bituminous to lignite, much better than many of the older deposits in the state of the same formation. They are located near Columbia Falls, which is north and east of Kalispell, also on the main line of the Great Northern R. R. The product of the mines is, for the most part, shipped west to Spokane, and also is used in Columbia Falls, Kalispell, etc. This coal is not of the coking kind.

According to the latest developments there are three fields in this county, located on the North, Middle and South Forks of the Flathead river. The only real work has been done on the North Fork mines. The seams here are from eighteen inches to twelve feet thick and have a slight dip. There are several seams and the area of this field is quite large. The following are analyses of the North Fork product:

	Water and Volatile Matter.	Fixed Carbon.	Ash.
North Fork......No. 1	50.15	40.25	9.60
North Fork......No. 2	48.20	41.20	10.60
North Fork......No. 3	52.55	36.58	10.87

The material found in the North Fork mines is a semi-bituminous coal.

Missoula County.

Missoula county, directly south of Flathead county and crossed by the main line of the Northern Pacific Ry., has several deposits, the best being a short distance from the city of Missoula. This is all lignite, and while there have been several attempts to work the various places, it has not proved of commercial value and none has been placed on the market. Unless the material be made into briquets it will be some time before the deposits will be used. Missoula county has an abundance of hematite iron ore, and in time the coals and cokes of the state probably will be utilized in smelting and refining this

valuable natural product. The geologic age of the lignite beds in this county is undoubtedly Neocene, probably White river.

Ravalli County.

This county,.with Hamilton as its county seat located on a spur of the Northern Pacific Ry., lies directly south of Missoula county. It has in its southern part some of the best lignite deposits in the state. They are nearly all easily accessible and the beds range from a few inches to 12 to 14 feet in thickness. One of the best of these southern fields is found on Coal creek, and measures 13 feet in thickness. This property has been worked to some extent. The material and geological formation is practically the same as found in Missoula county.

Teton County.

Here is found some Cretaceous coal of a semi-bituminous nature, a few miles south and west of the town of Chouteau—between the 112th and 113th meridians W., and the 47th and 48th parallels N. This outcrop is just north of the northern fields in Lewis and Clarke county, and at the eastern base of the Rocky mountains.

Granite County.

This county is crossed by the Northern Pacific Ry. which has a spur from Drummond to Philipsburg; the latter town is located at the head of Hellgate valley and is the county seat of Granite county. There are many mines in this region but none yield a good grade of coal. The writer visited several mines and saw many samples, all of which were lignite. A great deal of prospecting is being done here, but the valley is an old Neocene lake bed and part of the lignite is undoubtedly Miocene vegetation. The lignite is a poorer grade than found in Ravalli and Missoula counties, and has a dull lustre and is quite friable. The mines in this county are near Drummond, a small town on the main line of the Northern Pacific Ry.; New Chicago, a small town up the valley from Drummond; Hall, a station on the Philipsburg branch, and Philipsburg. Much work at all of these places has been done during the past year, but none of the material has yet paid for the digging. Professor N. H. Winchell, during the past summer, visited some of the new coal prospects south of New Chicago and thinks the formation Jura-Trias. The Cretaceous occurs high-

er than the Hellgate valley, between Drummond and Gold Creek, and also north of Drummond, and in this formation a fair grade of lignite is found. It might be, however, that these three formations will all yield good lignite.

Beaverhead County.

This county has many natural resources including graphite, and lignite is found in several localities, but little development work has been done and not much is known of the thickness, extent, or geological formation of the beds.

Chouteau County.

This county is crossed by the Great Northern Ry., and cut from S. W. to N. E. by the Missouri river. Fort Benton is the county seat and lignite beds are found around this town. Also a large area to the north, occupying nearly all of the central portion of the county. This undoubtedly belongs to the plains Cretaceous formation.

Lewis and Clarke County.

This county has several coal outcrops north of Helena on the east base of the Rocky mountains. Near Rock creek is found some fair semi-bituminous Cretaceous coal, also in the northern part of the county near Augusta is found some fairly good mines of ordinary bituminous coal. But very little work has been done on these mines, and their extent is not known. However, the coal is of good quality and it is thought the places will yield well when developed. The beds in the northern part are probably a continuation of the Teton coal beds, and also a part of the Great Falls field.

Cascade County.

The Great Falls and Belt fields extend over a portion of this county, and one of the best developed districts is that of Sand Coulee and Cottonwood. These are small towns south and east of the city of Great Falls on a branch of the Great Northern Ry. Belt is another coal and coke producing town east of Sand Coulee on the Great Northern Ry. The mines from these places supply the coal and coke used in Great Falls and by the Great Northern railway. The coal is a fairly good bituminous variety and belongs to the Cretaceous formation. Other fairly good beds are found near the mouth of Smith river. Only a

part of the coal mined in this vicinity is coking. The upper beds are non-coking, but make a good steam coal.

Fergus County.

The Great Falls field also extends down into this county to the west of Lewiston, the county seat and the largest town without a railroad connection, in the state.

The Judith Basin field which forms almost a hollow square, surrounds Lewiston and lies between the 109th and 110th degrees W. long., and immediately north of the 47th parallel. There are several coal mines around Lewiston, and since this part of the country has become such a good mining district, much is expected from the coal product. The coal found here is semi-bituminous and belongs to the Cretaceous. Lewiston is supplied with coal from her own mines.

Powell County.

Neocene lignite is found in and around Deer Lodge which is the county seat of this county, located in the southern part of the county in the Deer Lodge valley. A semi-bituminous coal has also been reported as being found near Avon, a small town on the Northern Pacific Ry., north and east of Deer Lodge.

Deer Lodge County.

During the past year several good mines of semi-bituminous or lignite coal have been reported near Anaconda, the county seat of this county. Much development on these mines during the coming season is planned and the exact thickness of the beds and the kind of formation will be learned. They, doubtless belong to the Neocene period, however, Cretaceous outcrops are found near Anaconda. In sinking some of the earlier shafts one of the coal seams measured five feet, four inches, and gave the following analysis:

Volatile matter	45
Fixed Carbon	35
Ash	15
Moisture	5

Silver Bow County.

This county, with Butte as its county seat, and containing some of the richest copper mines in the world, has had no coal mines reported as far as the writer knows.

Jefferson County.

No coal or lignite of any consequence has been reported from this county.

Broadwater County.

Some coal has been found in this county near Toston, a small town on the Northern Pacific Ry. in the southeastern part of the county. It is bituminous and probably belongs to the Cretaceous formation. The area is small, but contains good coking coal. One portion yields a small amount of graphite.

Meager County.

In the southern part of this county, near the northern base of the Crazy mountains, are some semi-bituminous to bituminous beds. These belong to the Yellowstone field, while to the east of the Crazy mountains are found some beds which belong to the Clark's Fork field. The deposits in this county are being worked but very little if any. However, if Meagher county could furnish White Sulphur Springs, its county seat, with a cheap coal, her iron mines would soon be a source of great benefit to that city. Spencer and Menger have one of the best magnetite prospects the writer has ever examined. The vein is from 40 to 50 feet wide, but the extent otherwise is not known. The owners have sunk a shaft 30 to 40 feet going the entire distance through first class ore, and have prospected several hundred yards on each side of the shaft. All indications show it to be one of the best iron ore mines in the northwest.

Madison County.

Here is found the Ruby Valley field situated south of Virginia City, which is a Cretaceous formation (Laramie). While so far very little work has been done in this field, there are several outcrops. Some very good bituminous coal has been found near Ennis, a small town northeast of Virginia City. Future developments will doubtless yield fair results from this latter locality. According to recent reports, good bituminous coal has been found one and one-half miles east from Monida.

Gallatin County.

This county, located in the southern part of the state, is one of the best bituminous coal counties in the bituminous region. In the southwestern part of this county is found the West Gal-

latin field; this field is between the Madison and Gallatin rivers, and but very little development has been done. It is a long distance from a railroad, but has some fairly thick coal beds. The coal is bituminous coking coal and future developments will doubtless prove this to be a very profitable field. The formation is Laramie.

Another field, partly in Gallatin county, is the Trail Creek field. This field has some good beds and was recently connected with the Northern Pacific Ry. by a spur from Chestnut.

The third field in this county is the Yellowstone field. This occupies the north and eastern part of the county and is the most productive and largest of all the Gallatin county fields. The mines are mostly owned by the Northern Pacific railway company, and the coal from these mines is largely used in their locomotive engines. The coal is a good coking coal and for the most part belongs to the Laramie formation.

Park County.

This county, located in the southern part of the state, bordering on the Yellowstone, is also one of the foremost counties in the production of coal. It has parts of two coal fields within its boundaries and borders on the third. The most productive beds are found in the Shields River district of the Yellowstone field and in and around Cokedale, and the southern, Cinnebar field, on the west bank of the Yellowstone river near the town of Horr. The coal from the Cinnabar field is in several beds. Some of these beds have been greatly altered by near-by volcanic action, and furnish semi-anthracite coal. The other beds contain a good grade of bituminous coking coal, and there are between three and four hundred large coking ovens at Horr, a small mining town situated on the Northern Pacific Park line, only a few miles from Gardiner, the terminus of the Park line and the entrance to the Yellowstone National Park.

Sweet Grass County.

There are parts of two fields in this county. The northern part is crossed by Clarks Fork field, and where coal is found it is of the plains kind, being removed from the mountain movement. The original strata have been but little, if any, changed and the coal found would naturally belong to the semi-bituminous or lignite variety. The formation is Cretaceous, and the fuel found is for the most part lignite.

In the western part of the county is found a portion of the Yellowstone coal field, which lies south and west of Big Timber.

Carbon County.

In the eastern and south-central parts of this county are found some very productive coal beds. The eastern portion is covered with the Clarks Fork field, which yields a good grade of semi-bituminous coal, and at Gebo and Bridger, a large amount of this material has been taken out. This same field extends southward into Wyoming, and there is known as the Big Horn Basin field.

The south-central beds embrace the Rocky Fork field, and yield a semi-bituminous coal or a good grade of lignite. The mine most productive in this field is the one at Red Lodge, the county seat of Carbon county, located on a spur of the Northern Pacific Ry. This is probably a lower Tertiary formation.

Yellowstone County.

Yellowstone county has the Clarks Fork field all along the northern part and the Bull Mountain field in the northeastern part. This portion of the Clarks Fork field in this county yields but very little coal. The formation is Laramie and the variety of coal is lignite. The fuel found in the Bull Mountain field is a post-Laramie formation or probably Eocene, and yields the best grade of all of the lignite fields in the state. Thus far the county is not very productive although the farmers and ranchers get a good fuel for the mere digging.

Custer County.

This county is one of the richest in the state in the production of lignite. Miles City, its county seat, is literally surrounded with this natural fuel. Several mines were visited near this place and all were in a flourishing condition. One of the best mines is owned by the Electric Light company and is about three miles from town. The coal seam is forty-five feet from the surface and three feet ten inches thick. It is capped by a slate colored leaf-bearing clay and underlain by a thin layer of "bone" and then fire clay. This mine supplies all the fuel for the Elecric Light plant of the city, and many use it entirely for domestic purposes, especially in the furnaces.

Outcrops of lignite may be seen all along the bank of the Yellowstone river, both above and below Miles City. The seams are six to eight feet thick above the town, on Coal and Lignite creeks, but thin out to the eastward. Lignite is also very abundant in the southern part of this county. Twenty-one miles south and west of Wibaux, on the west bank of Beaver creek, is an outcrop ten feet thick. Also near Ekalaka and Powderville lignite is very plentiful, some of the seams measuring from fifteen to twenty-five feet in thickness. All of these beds belong to the Laramie and furnish a good fuel at a very low price.

Dawson County.

From Custer county, north and east, the lignite passes into Dawson county. But little lignite is found between Conlon and Glendive, however, there are many good outcrops east of Glendive. The Electric Light plant at Glendive uses the near-by lignite entirely for their work, as do also many other establishments of the city. There are some very good outcrops of coal from Glendive to Wibaux, on either side of the Northern Pacific railroad, and the citizens of the latter place use lignite that is found within three miles of town almost exclusively. There are several good mines three or four miles both north and south of Wibaux, but the best ones near, are found on Glendive creek, about eleven miles south and east of town. At the latter place the lignite is over twenty feet thick and of a good grade. All of the beds examined in this county belong to the Laramie formation.

Rosebud County.

Lignite is found in many places in this county and the people outside the towns use it almost entirely as a fuel. Among the best beds visited are those near Forsyth, the county seat of this county. These beds are located seven miles south of Forsyth, at the head of Smith creek, a dry branch of the Yellowstone river. This mine is operated to some extent and furnishes considerable fuel for the citizens of Forsyth. The quality of this lignite is among the best examined in the state. The seams range from four feet, eight inches to eight or ten feet thick and cover a large area. Some of the seams have a coarse conglomerate for a capping, while others are capped by sand-

stone and still others by a dark grey soapstone. That covered by conglomerate is absolutely worthless, while the soapstone-covered lignite is by far the best found in this section. The outcrops extend a few miles west of Forsyth and the county is well supplied in the western and southern portions. That around Forsyth and west, is Laramie, and doubtless the other lignite beds in the county, are also Laramie.

Valley County.

While the writer has never examined the formations north of the 48th parallel, in the eastern part of the state, indications are, that lignite beds are quite abundant in Valley county as well as the other eastern counties. Reports have come in from the Big Dry country, stating that there are many large outcrops of lignite in that part of the county. Like reports have been had from Culbertson a small town on the Great Northern railroad. Thus it may be seen that all but two of the twenty-six counties in the state, yield a fair quality of natural fuel.

NOTES ON THE GEOLOGY OF EASTERN NEW YORK.

By CHARLES S. PROSSER, Columbus, Ohio.

The Mohawk Valley sections.—Since the preparation of the writer's sections in the Mohawk valley and Saratoga county* Messrs. J. M. Clarke and Charles Schuchert have proposed Lowville limestone for the Birdseye and used Lorraine beds in place of the Hudson River† and these names should be substituted for the synonymous ones used in my sections Still later Dr. Clarke has proposed the name Little Falls dolomite for the Calciferous of the Mohawk valley.‡

Professor Cushing has also fully described the crystalline pre-Cambrian rocks at Little Falls and shown them to be syenite cut by two diabase dikes.§ From Trenton Falls south-

* "Sections and thickness of the Lower Silurian formations on West Canada creek and in the Mohawk valley," by CHARLES S. PROSSER and EDGAR R. CUMINGS, *15th An. Rept. State Geologist* [N. Y.]. 1897, (1898), pp. 615-660; and "Notes on Stratigraphy of Mohawk valley and Saratoga county, New York." *Bull. N. Y. State Mus.*, No. 34, May, 1900, pp. 469-483.

† *Science*, N. S., vol. x, pp. 876, 877.

‡ See University of the State of New York. *Handbook*, 19, July, 1903 pp. 9, 16.

§ *Twentieth Rep. State Geologist* [N. Y.], 1902, pp. r83, r93.

easterly to the Little Falls and Canajoharie region the typical Trenton limestone thins rapidly and probably the lower portion of what has generally been referred to the Utica shale in this latter region was deposited during the same time as that of the upper Trenton limestone of the former locality. About Little Falls there are alternating beds of limestone and shale which, lithologically, are transitional from the Trenton to the Utica. These beds are more fossiliferous than the usual Utica shale and, possibly, can be referred to the Trenton limestone; or, perhaps it will be better to consider them a "zone of Trenton-Utica passage beds" as has been done by professor Cushing in his geologic map of the Little Falls quadrangle.*

The Helderberg sections.—In the reports of the state Geologist of New York the author has published various sections in the Helderberg plateau of Albany and Schoharie counties.†

Later investigations of other geologists have added to our knowledge of these formations and Mr. Schuchert has shown that the age of two formations is not that which had generally been assigned to them. The Coralline limestone, now named the Cobleskill by Dr. J. M. Clarke, was in 1852 correlated by Prof. Hall with the Niagara limestone‡ while the subjacent green pyritiferous shale was, apparently, referred to the Clinton group. This opinion was evidently held by Professor Hall until his death for in Mr. Darton's description of the Helderberg limestones, a report prepared under Professor Hall's direction, is a foot note by Hall stating that "The Niagara ('Corraline') limestone crops out along the road going obliquely up the hill at the northeasterly end of the village of Schoharie, and continues for more than a mile along the northerly escarpment of the terrace."§ In the text Mr. Darton used the names Niagara limestone and Clinton formations with, apparently, Professor Hall's acceptance for these two formations as exposed at Howe's Cave and Schoharie.‖ In my sections in the vicinity of these two villages the correlation of Professor Hall was accepted and followed for these two divisions which were called the Clinton

* Letter of Prof. H. P. Cushing, Feb. 17, 1902.

† "Stratigraphic Geology of the Eastern Helderbergs." *Seventeenth An. Rep. State Geologist*, 1899, (1900), pp. 329-342. "Sections of the formations along the northern end of the Helderberg Plateau. 18th *ibid*, 1899, (1901), pp. 51-73.

‡ *Pal. N. Y.*, vol. ii, p. 321.

§ *Thirteenth An. Rep. State Geol.*, 1894 [1895], p. 218.

‖ *Ibid*, p. 218; see also plates 1, 3 and 4.

shales and Niagara ("Coralline") limestone.* Mr. Schuchert has now shown that the Cobleskill (Coralline) limestone is of later age than the Niagara, forming the lower member of the Manlius formation † and this change should be made in my sections cited above. It is to be noted in this connection, however, that Dr. Clarke regards the Cobleskill dolomite as a unit formation succeeding which are the Rondout waterlime and Manlius limestone at the top of the Upper Silurian system. Mr. Schuchert also states that the subjacent green shale of Schoharie county cannot be the Clinton "but probably is the thinned eastern edge of the lower part of the Cobleskill of the Litchfield section [Herkimer Co., N. Y.‡]," "although in a paper of the previous year Messrs. Ulrich and Schuchert stated that they considered "the so-called 'Clinton' of the Schoharie section... the overlapping eastern edge of the Salina deposits."§ Mr. Schuchert has written me as follows regarding this change: "It seems more natural to refer the hiatus to beneath these shales and above the upturned Hudson rather than between the 'Clinton shales' and the Manlius. If they are Salina in age there must be a short hiatus between them and the Manlius. However, I think it more natural to regard these shales as the invading base of the Manlius. They appear deeper and deeper (i. e. older) in the sections from Albany county into New Jersey. The invasion is from the south."‖

In my section one-half mile south of New Salem and west of the Markel house, ten inches of greenish sandstone to coarse, arenaceous shale, directly beneath the Waterlime (Rondout) was stated to represent, possibly, "the attenuated *Clinton* formation."¶ Mr. Schuchert concludes that this layer is not to be correlated with the Clinton but may be "regarded as the invading basal deposits of the Rondout."°

Since the publication of my work in the Helderberg region Dr. Clarke and Mr. Schuchert have used the name Lorraine beds for the upper part of the Hudson River beds in the Mo-

* *Eighteenth An. Rep. State Geologist*, 1899 [1901], pp. 66-68.

† *Am. Geol.*, vol. xxxi, pp. 175-177.

‡ *Ibid*, p. 176 and on p. 173 under description of Schoharie section is the statement that "the age of these olive green shales seems to be Lower Cobleskill."

§ *N. Y. State Museum, Bull.* 52, 1902, p. 650, f. n.

‖ Letter of May 10, 1903.

¶ *17th An. Rep. State Geol.*, 1899 [1900], pp. 338.

° Am. Geol., vol. xxxi, p. 178.

hawk and Hudson river valleys,* although in the last paper by Mr. Schuchert they are called Frankfort shales.† In the former paper Messrs. Clarke and Schuchert proposed the following geographic names to replace names of stages which had not been so derived. Rondout waterlime for the Waterlime, Manlius limestone for the Tentaculite, Coeymans limestone for the Lower Pentamerus, and New Scotland beds for the Catskill or Delthyris shaly limestone. These later names are now to be substituted for the corresponding ones used in my sections of the Helderberg region.

The upper part of the Manlius (Tentaculite) limestone has been termed transitional by the writer, meaning that the layers in general are thicker than those composing the lower and greater part of the Manlius and that a few species, which had been supposed to be confined to the superjacent Helderbergian limestones, occur in these beds. These characters were, formerly, admirably shown in the extensive quarries at Howe's Cave, where there is a very marked line of division between the top of this zone and the Coeymans limestone. It was not intended to separate this zone from the Manlius limestone in which it was included and where the writer still believes it to belong. In the Countryman Hill section perhaps the top of the Manlius limestone is slightly higher than indicated by the writer, and yet the total thickness of this limestone in this section, 46 feet, agrees closely with that obtained by the writer and other geologists in the Helderberg region. At this locality the writer described the massive ledge of Upper Pentamerus limestone near the house of Mr. K. P. Parish, which he incorrectly called the Becraft limestone. The Becraft limestone of professor Hall is composed in the Schoharie-Helderberg region of the Scutella and Upper Pentamerus limestones. The writer, however, only saw the Upper Pentamerus; but he is informed by Miss Mignon Talbot, who has spent part of two summers in studying this section, that the Scutella limestone is well shown a little to the east and below the Parish ledge of Upper Pentamerus, with a thickness of about four feet. This thickness is to be added to the thirteen feet of Upper Pentamerus limestone making a thickness of seventeen feet for the

* *Science, N. S.*, vol. x, pp. 876, 877.
† AM. GEOL., vol. xxxi, pp. 172-174.

Becraft limestone. In this section the upper part of the New Scotland (Shaly) limestone was covered and the top was drawn at the base of the Upper Pentamerus ledge, giving a thickness of 120 feet for the formation. From this thickness is to be deducted that of the Scutella limestone, leaving 116 feet for the New Scotland beds.

The Chenango-Otsego region.—The classification of the formations in the Chenango valley as given in 1898* the writer would now change to the following form:

Chautauquan series....Chemung stage.

Senecan series.....
- Portage stage
  - Oneonta sandstone.
  - Unadilla formation
    - Ithaca member.
    - Sherburne member.
- Genessee shale.
- Tully limestone.

On the map accompanying the above report the Sherburne and Ithaca beds were mapped together as one formation; but no name was proposed for it. It is now considered better to give this terrane a distinctive name and therefore it is called the Unadilla formation.† It is named from the Unadilla river, which below New Berlin village, is bordered by steep hills that begin in the Sherburne beds, contain the entire thickness of the Ithaca beds and are capped by the Oneonta sandstone. It ought to be mentioned in this connection that Dr. H. S. Williams does not consider the marine fauna succeeding the Oneonta sandstone in the Chenango valley "as high as the typical Chemung formation of western New York."‡

The Catskill formation given in the former classification is the local facies representing in different localities a time interval varying in length from that of a portion to the entire time of one or more stages. In Broome county in southern New York it probably represents in age the upper deposits of the Chemung stage in southwestern New York, while in its typical region on the eastern slope of the Catskill mountains in southeastern New York it began as early as the Sherburne beds and continued during the remainder, at least, of Devonian time.

Columbus, Ohio, July 24, 1903.

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* *15th An. Rept. State Geologist (N. Y.)* p. 95.

† See University of the State of New York. *Handbook*, 19, July, 1903, p. 24.

‡ *U. S. Geol. Surv., Bull.* 210, 1903, p. 96.

EDITORIAL COMMENT.

METAMORPHISM OF THE LAURENTIAN LIMESTONES OF CANADA.

On the petrographical relations of the Laurentian limestones and the granite in the township of Glamorgan, Haliburton couuty, Ontario. LOUIS CARYL GRATON, (Can. Rec. Sci., vol. ix, pp. 1-38, Jan., 1903.

This important paper, prepared under the direction of Dr. Frank D. Adams, illustrates and enforces the recent advance that has been made in Canada in methods of geological research. The rocks here treated of (at least the same rock horizon) have been many times reported on and some old and fundamental truths are now confirmed as the result of attention and minute field observation, coupled with rational consideration and microscopical inspection. Some of the new (?) views are so revolutionary that when applied widely they threaten to modify greatly the long accepted classification of the Canadian Laurentian, and the "fundamental gneiss" which is said to lie at the base. Some of the results may be enumerated as follows:

Countless rounded bosses of bare rock, "identical in appearance with the fundamental gneiss, have penetrated and eaten into the white crystalline limestones" belonging to the Grenville series.

Dr. Adams has found in recent studies in this area that the Grenville limestones, which are always much altered, are, at the contact of the "fundamental gneiss," transformed into dark basic rocks which still retain the banded structure of the limestone, in a manner somewhat similar to that described by Lacroix in the Pyrenees. Here the "fundamental gneiss" contains many inclusions of dark basic rock which near the contact are more angular in form, and away from the contact assume the form of dark elongated streaks in the "fundamental gneiss." The field relations are such that "it seemed practically certain that these fragments were portions of the basic contact rock in a still more highly altered condition which had floated away in the igneous mass during the process of intrusion." At the same time there are bands of amphibolyte in the limestone away from the intrusions.

Hence, the alternative questions arise: (1) Has the "fundamental gneiss" been reheated and caused to invade the

Grenville series? (2) Has there been an intrusion of later igneous material identical with the "fundamental gneiss"? and (3) Is the "fundamental gneiss" as a whole younger than the Grenville series, although hitherto supposed to be older? The author entertains only the first two of these, but to the reviewer the third query is equally worthy of consideration.

The author seems to presume that the field evidences are not conclusive, and that a microscopical examination is necessary, coupled with chemical analyses, in order to confirm the field conclusions. The writer has elsewhere discussed the comparative value of field and microscopical evidence in the deduction of such general conclusions.* He is disposed to follow the field evidence, correctly observed, rather than the microscopical, when they seem to collide. But when, as in this case, they confirm each other, there is no reason for further investigation on the points involved, and, it may be added, the field structures that have been seen and the inferences derived from them, are probably equally valid for other similar cases of Archean geology. There is no question but the stratigraphical methods of field geology have been reinforced in this instance by the careful microscopical examination of numerous thin sections.

The specific object of the paper is two-fold: viz., (1) to determine the origin of the basic contact rocks by petrographical methods, (2) to learn the true character of the seeming inclusions by the same methods. As already stated, Dr. Adams had already answered both these question by field studies; and, as also already stated, the author's results confirm the conclusions reached in the field. "These limestones are the same white or pinkish crystalline limestones or marbles everywhere characteristic of the Grenville series, which have been described at length by Dr. T. Sterry Hunt and various other writers. * * * * Away from the intrusions before described the limestones are comparatively pure, though they sometimes contain bands of very dark hornblendic rocks or amphybolytes; but approaching the igneous rocks they are found to contain little rounded grains of pyroxene and other lime-rich minerals, and in many cases to pass into banded basic rocks which warrant the field name of pyroxene gneiss. These

* Fourth Annual Report of the Minnesota Survey (for 1891), pp. 18-22.

become darker in color, yet nearer the granite, and are still found to contain intercalated with them and with layers of limestone, bands of amphibolytes, which have a harder and more granitic look than the pyroxene gneisses, but are otherwise quite similar in appearance. They are somewhat more sharply defined from the marbles than are the pyroxene gneisses, the transition from one to the other being often quite abrupt. The whole series is cut by dikes, veins or stringers of the granite which anastomose through it in a remarkable way, and the resulting appearance is most complicated. Nearer still to the invading mass these bands become more and more broken and indefinite, the number and size of the granite dikes increase; and at last comes the state of affairs where the dark rocks occur as inclusions in the granite. In the southwestern portion of the large central batholith shown in the accompanying map, these inclusions are very numerous indeed. They vary in size from a few square inches to hundreds of yards, and have an appearance very similar to the rocks of the bands at the border, looking, however, still a little harder. Farther and farther away from the contact they lose much of their angular form and appear simply as dark elongated streaks in the granite, which seems to be dissolving or absorbing them." (pp. 5-6).

The author describes in detail the microscopic characters of several thin sections with view to discover by comparison the source of the derived rocks.

The foliated and banded red granite (1273) which is supposed to be the intrusive that has metamorphosed the limestones, has a structure parallel with that of the adjoining limestone. It consists of the elements usual in granite, quartz, oligoclase, mircrocline, orthoclase and biotite. It also embraces muscovite, magnetite, pyrite, zircon and apatite. It is granular and allotriomorphic.

The gray gneiss (1268) is very quartzose, granular in structure, approaching mosaic, and does not greatly differ from the last, embracing the same minerals, though the feldspar here is andesine in place of oligoclase. This gray gneiss is in patches in the red.

A quartz dioryte gneiss (1271) is without distinct foliation, fine-grained, granular and light reddish gray. The orthoclase in this rock is so scant that it receives the name dioryte, though

it is not essentially different from the foregoing. Hornblende in this rock is, however, not mentioned.

Another quartz dioryte gneiss (1275) is distinctly foliated and contains, with the minerals of the last, also hornblende, more orthoclase and some sphene. Its structure is granular.

The altered limestones "constitute the dark basic rocks interbanded with the limestones near the granite contact." They are pyroxene gneiss or amphibolytes according to the presence of pyroxene or of hornblende. A pyroxenyte (1269) is very fine-grained, friable, greenish-gray, and distinctly banded, being made up of dark-colored bands alternating with bands of medium and light color. The dark bands are composed almost exclusively of plagioclase, hornblende and augite. The lighter ones are intergraded amongst themselves, by reason of banded variations in the relative proportions of the constituent minerals. These minerals are combined as plagioclase, scapolite, augite; plagioclase, microcline, calcite, augite; plagioclase, calcite, augite, with subordinate amounts of quartz, sphene, apatite, hornblende, ilmenite, epidote and biotite. The structure is granulitic, with mosaic appearance.

A scapolite amphibolyte (1272) is fine-grained, somewhat friable, greenish-gray, foliated and banded in darker and lighter bands. The darker bands consist essentially of hornblende with scapolite, and the lighter of the same with more scapolite, while as accessories are calcite, pyroxene, labradorite, quartz and sphene. Structure is granulitic with a mosaic of polygonal grains.

An amphibolyte (1270) consists of hornblende and labradorite, essentially, with small amounts of quartz, scapolite, calcite, orthoclase and augite, and still smaller amounts of sphene, titanic iron ore and apatite. The structure is granulo-granulitic, "but still points to recrystallization of the component minerals."

The dark masses included in the granite are often near areas of gray gneiss. They grade in "form, appearance and composition, from angular, black and exceedingly basic near the contact to lenticular masses with alternately light and dark bands, and less basic farther away in the granite mass." An amphibolyte (1267 A. B. C.) of this source consists microscopically largely of hornblende with a considerable amount of

labradorite, with accessory quartz, andesine, biotite magnetite, pyrite, apatite and zircon. The structure is granulitic to granular.

A quartz dioryte gneiss from an inclusion (1274) is dark gray, foliated and banded, in which composite bands alternate with light-colored and dark-colored bands. It is composed essentially of quartz, oligoclase and hornblende, while in certain bands biotite is common, and in others microcline occurs. Accessorily are found also orthoclase, sphene, ilmenite and apatite. The structure approaches granitic, the grains partially interlocking. "The rock seems in fact to have approached very closely, both in structure and in composition, to the gneiss which lies near it."

Making a mechanical separation of the mineral constituents of the rock samples studied, the author tabulates them under the heads: basic constituents, calcite, scapolite, labradorites, andesite, oligoclase, quartz, microcline and orthoclase. He finds by this that the basic minerals are most abundant in the pyroxenytes and the amphibolytes along the contact zone; that the gray gneisses which are "in patches in the granite," are hardly distinguishable from some of the masses that are distinct inclusions; that the basic inclusions are prevailingly hornblendic (amphibolyte) while the contact basic rocks are more frequently augitic (pyroxenyte); that both the inclusions and the contact rocks contain labradorite; that the inclusions, whether basic or acid, contain no scapolite nor calcite, but at the contact zone these minerals are both common; that oligoclase, quartz and microcline are in the foliated granite, the gray gneisses and in the quartz-dioryte granite, but that in a gray gneiss in which quartz is abundant (51 p. c.) andesine takes the place of oligoclase.

In making a final inquiry as to the origin of the basic rocks at the contact and as to the real nature of the dark streaks and patches held by the gneissic granites, the author remarks:

"The principal materials which must have been added to the elements of the limestone to produce the various silicate minerals observed in the altered limestones are: silica, alumina, iron, magnesia, alkalies, and clorine (for scapolite.) As to the source of these materials, there are two possible explanations; either they existed in the limestone or in the beds interstratified

officers offered other reasons for these evidences, and constantly harassed the commander with suggestions that he was probably off the line of pursuit. They insisted on the discovery of the enemy's initials on the old canteens and manufacturers' stamps on the rejected muskets. The commander gave no heed to them, but continued the pursuit, and on coming up with the retreating army, succeeded in surrounding and capturing it *en masse.* The subordinate generals then admitted that the evidences that the commander had depended on appeared to them less and less irrational.

Hutton started this investigation of the oldest rocks and followed in the line of the plainest field evidence. Most geologists rationally agree that he took the right direction, and have accepted his guidance, but it is only reluctantly that the extreme plutonists have yielded step after step, after insisting on the minutest chemical and microscopical comparisons. It is a satisfaction to know, however, that after such minute examinations the most scrupulous caution is satisfied, and that Hutton and his followers in England, and those who belong to the so-called French school on the continent and in America, are apparently confirmed in their main conclusions.

N. H. W.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Geologic Atlas of the United States.

The following folios have been received from the United States Geological Survey, C. D. WALCOTT, director, viz: Nos. 87-93. The individual authors contributing to these folios, and the names of the folios, will be found listed in the alphabetical Author's catalogue of recent literature.

Index to publications of the New York State Natural History Survey and New York State Museum, also including other New York publications on related subjects, 1837-1902. MARY ELLIS. New York State Museum, Bulletin 66, Miscellaneous 2, pp. 653. Albany, June, 1903.

This very welcome and useful volume makes more available the great mass of literature on natural history subjects which has been published at Albany. It might be supposed from the title that all New York publications are here listed and indexed, but, aside from the survey

and the Museum publications, the author has included only the Transactions of the New York State Agricultural Society, and the Transactions of the Albany Institute. There is a special index to descriptions of genera and species of fossils prepared under the direction of John M. Clarke, occupying pages 527 to 653. N. H. W.

New York State Museum: 55th Annual Report of the Regents, 1901. Pages r166, 991, with many plates. Published by the University of the state of New York, Albany, 1903.

The report of the director of the State Museum and state geologist, Dr. Frederick J. H. Merrill, with numerous included papers by his assistants, fills 166 pages. It is accompanied with 36 plates, the first being a contour map of the state, on the scale of 12 miles to an inch, folded in an envelope pocket of the cover. Geological papers are contributed in this report by J. B. Woodworth, H. P. Cushing, H. L. Fairchild (as reviewed in the October AM. GEOLOGIST, p. 250), Arthur Hollick, Heinrich Ries, and E. C. Eckel.

In the latter part of this volume, important paleontologic papers, with admirable plates, are presented by the state paleontologist, Dr. John M. Clarke, his assistant, Dr. Rudolf Ruedemann, and Elvira Wood. W. U.

The Mineral Resources of the Mount Wrangell District, Alaska. By WALTER C. MENDENHALL and FRANK C. SCHRADER. (U. S. Geol. Survey, Professional Paper No. 15, 71 pp., 10 pls., 1903.)

In this paper the authors have presented the results of their own work in the summer of 1902, and have added to it from previous reports (chief of which are those by F. C. Schrader and A. C. Spencer, and by C. W. Hayes) so as to present an account of what is known t· date concerning the mineral resources of the district. This report is issued in advance of the contour map and a report on the general geology of this region, but a hachured map accompanies the present report.

The Mount Wrangel district extends from Valdez on the west to Mt. St. Elias in the east, and from the Pacific ocean on the south northward for about 250 miles. This district includes practically all the drainage basin of the Copper river, and towards the northeast includes considerable parts of the basins of the White and Tanana rivers, tributaries of the Yukon.

The chief copper deposits of the district occur in the vicinity of the Chitina river which enters the Copper river from the east. Geologically this area is underlain by rocks of four different series, as follows: (1) the Nikolai greenstone which is a more or less altered series of lava flows of presumably Carboniferous age; (2) the Chitistone limestone, Permian in age; (3) Triassic shales and limestones; (4) the Kennicott formation, consisting of conglomerates, sandstones, limestones and shales of Jura Cretaceous time. The first three series are conformable and are considerably folded, while the fourth lies unconformably upon the others. Cutting all is a series of eruptives. The copper occurs near the junction of the greenstone and the Chitistone

with it before the intrusion took place, and were subsequently metamorphosed and recrystallized; or they have been derived in some manner from the substance of the intrusive mass. The question resolves itself then into one of metamorphism by digenesis or by metasomatosis."

The author gives no analyses of the limestones in their non-metamorphic condition, but assumes that they are "in general comparatively pure." He gives no analyses of the intrusive granites, but he assumes that these substances have been introduced into the limestones by metasomatosis from the granites, and hence that, while they are distinctively banded, in the manner often regarded as sedimentary, the origin of the new substances as well as their distribution in the limestone, date from the act of intrusion and are due to that intrusion—*i. e.* that the metamorphism is a species of extreme metasomatosis.

To the reviewer the discussion seems to be a curious instance of arguing against a mass of adverse facts, and the alternative rejected is apparently more concordant with the facts than that which is accepted. The assumption that the limestone is comparatively pure away from the contact zone is gratuitous. It would be perhaps more reasonable to presume *a priori* that such impurities as "silica, alumina, iron, magnesia, alkalies and chlorine (for scapolite)" in the words of the author, existed primarily in an unanalyzed limestone rather than in an unanalyzed granite, *i.e.* in quantities sufficient to give rise to the new minerals. There are also plain inferences from the facts given that the impurities mentioned were originally in the limestone. One or two may be stated, viz: calcite, which necessarily existed in the limestone in largest amount, diminishes toward the granite. It is found in some amount still in the basic metamorphosed zone; it is absent in the inclusions, and is not known in the granite. Again, scapolite, whose characteristic substance (chlorine) is accepted as indicative of the origin of the impurities, occurs in the metamorphic zone near the limestone, but the basic inclusions within the granite, having the same source as the metamorphosed zone, more remote from the limestone, do not contain it, and it is unknown to the granite proper. If these substances were derived from the granite by metasomatosis they should be found more abundant in the gran-

ite than in the limestone, at least their frequency should increase toward the granite. According to the author the reverse is the fact.

It is apparent that the author does not rely implicitly on his conclusion, since he refers semi-approvingly to the hypothesis of Michel-Levy and other French geologists to the effect that the granite as now seen, and the associated crystalline rocks, are products of the fusion of sedimentary rocks. There may have been in all the cases studied, an original deeper seated granite which was intruded into and absorbed the sedimentary rocks. "Of so-called intrusions [inclusions?] in the granite Lacroix says: 'Je considère donc toutes ces couches metamorphiques isolés aujourdhui au milieu du granite comme le résidue non digéré des assises sédimentaires dont le granite a pris la place.'

"If these views are correct, they would serve to explain nearly every phenomenon observed in this occurrence in central Ontario. But the great weakness in them is the lack of chemical proof. Till that is at hand it may be said that 'while the transfusion of a certain amount of material into the limestones along the immediate contact of the intrusions, and also a solution of the limestones to a limited extent in certain cases seems highly probable, the wholesale transformation of limestone into dioryte, or of shale into gneiss and granite—is as yet very far indeed from being proved.'* It may be said in their favor, however, that as the study of this area has gone on these views have come to appear to the writer, at least less and less irrational." (p. 37). In other words, the views of Hutton, in this instance as in many others, who deduced his results from broad as well as minute, observations of the macrostructures of crystalline rocks as exhibited in the field, and who believed that the banded gneisses and schists, as well as the granites, are modified conditions of clastic rocks, are becoming, in the opinion of the microscopist as well as of the chemical geologist, "less and less irrational."

After a battle the defeated army retreated in the night. The victorious general pursued next day. It was plain, by the appearance of the road, the occurrence of canteens and rejected guns, where the enemy had passed, but the subordinate

* ADAMS. *Jour. Geol.*, vol. ix, p. 46, 1901.

limestone, sometimes in one and sometimes in the other, but more commonly in the greenstone. The ore minerals are native copper and the sulphides (chalcocite, bornite and chalcopyrite) which are superficially altered in small part into oxides and carbonates; bornite is the usual ore of the district. The deposits may be divided into vein and "bunch" deposits, the former being more important; the latter appear to be segregations in the greenstone. Some encouraging results have come from the prospecting which has been done in a few places. The authors call attention to the fact that the present deposits at the surface probably represent the enriched sulphide zone, and that lean sulphide deposits (chalcopyrite) will probably be encountered at no great distance below the surface.

The copper deposits just mentioned are south of the Wrangell mountains. The results and prospecting north of these mountains and within the limits of the district here reported on were not extremely encouraging up to the end of the summer of 1902, but copper was found in a number of localities.

Other mineral resources of the district are here discussed; they are gold, silver, platinum, tin, mercury, osmiridium, iron and coal. Gold is the most important of these and has been found in small amounts in several places, the most important of which is the Shistochina field, a placer district from which the output for 1902 is estimated at $225,000. In the diorite of the Nebesna River region gold is found in small quantities apparently combined with the pyrite which is so freely dissemminated through the rock. The reported occurrences of platinum in the gravels of the Nadina river were not confirmed by examinations made by Messrs. Mendenhall and Schrader. Coal has been reported from a few localities, but as yet little is known concerning its occurrence and value. U. S. G.

On a new lilac-colored transparent spodumene. By GEORGE FREDERIC KUNZ. Science, N. S. vol. 18, p. 280, Aug. 28, 1903.

Kunzite, a new gem. By CHARLES BASKERVILLE. *Science*, N. S. vol. 18, pp. 303-304, Sept. 4, 1903.

Spodumene from San Diego Co., California. By WALDEMAR T. SCHALLER. Bull. Dept. of Geol. Univ. of Calif., vol. 3, pp. 265-275, pl. 25-27, Sept., 1903.

Recent finds of deep amethystine purple, rose and magenta colored spodumene have been reported from near Pala in San Diego county, California, and to these the name kunzite has been applied as a designation for gem spodumene of these colors. The first two articles listed above are short papers dealing with this find, while the last paper gives more detailed facts concerning the occurrence, crystallography, etch figures, physical properties and chemical composition of this spodumene. The spodumene occurs in a pegmatyte dike (which cuts a basic dioryte) in connection with other lithia minerals, as lepidolite and tourmaline. The spodumene, however, occurs in pockets and seems to be of later date of formation than the tourmaline and the other minerals of the pegmatyte. U. S. G.

Elements of Geology, a Text-Book for Colleges and for the General Reader. By JOSEPH LE CONTE; revised and partly rewritten by HERMAN LE ROY FAIRCHILD. Fifth Edition, revised and enlarged, with new plates and illustrations. Pages xii, 667; with 1002 figures in the text. New York: D. Appleton & Co., 1903.

Seven years have passed since the last previous revision of this most popular text-book of geology in use by colleges and universities of the United States; and twenty-six years since its first edition. Although Dana's Manual is indispensable for the field worker and specialist, this less detailed, but yet widely comprehensive work is generally found more satisfactory for class instruction. Both treat very largely of American geology, and are therefore desirable for American students; while the grand English text-book of Sir Archibald Geikie, just now appearing in its fourth and enlarged edition, deals more fully with the geology of the British Isles, and of all the eastern hemisphere.

Professor Fairchild, since the death of Le Conte two years ago, has extensively revised this volume, strengthening it in many parts by the latest results of geologic researches throughout the world, and especially from the geological surveys of the United States and Canada and of the various separate states. Some sections have been largely rewritten, and several new topics are inserted; in which, as is remarked in the preface, "the spirit and style of the revered author have been held as the model." Assistance is acknowledged to John M. Clarke, on Paleozoic invertebrates; David White, Paleozoic and Triassic plants; T. W. Stanton, Postpaleozoic invertebrates; C. R. Eastman, fishes; F. E. Lucas, reptiles and mammals; C. E. Dutton, earthquakes; C. R. Van Hise, metamorphism; T. C. Chamberlin, earth genesis, etc. Many new illustrations appear, including a large number from photographs, which add greatly to the attractiveness and instructiveness of the work.

The planetesimal hypothesis of the genesis of the solar system, including the earth, as recently advocated by Chamberlin, differing much from the nebular theory of Laplace, and from its meteoritic modifications by Lockyer and G. H. Darwin, is thought to afford to geology a vastly extended duration of the earth and sun, far exceeding former computations by astronomers.

Postglacial time, the unit from which geologic estimates of the age of the earth have been made, in combination with probable ratios of the preceding long periods and eras, is left without decision in favor of either the geologically short period of about 7,000 years, thought by some to measure the erosion of the Niagara gorge, or the long period of 70,000 years which is advocated by others. But a preference for the lower estimate is perhaps shown by the acceptance of Prof. N. H. Winchell's computation of about 8,000 years as the time required for the erosion of the Mississippi river gorge between Fort Snelling and Minneapolis, cut by the Falls of St. Anthony since the Ice age. From the studies of Niagara by Wright and by the present reviewer, coinciding approximately with that of Winchell and with the large number of estimates and computations for the length of the Postglacial period, col

lected by Hansen from many observers in America and Europe, it certainly seems to be well demonstrated that this period is about 7,000 to 10,000 years.

High uplifting of the land areas which were glaciated is shown to be the primary and chief element in the causes of the Ice age, partly by the prevailing cold and snowy climate normally due to the land elevation, and partly by the effects of diminution of the amount of carbon dioxide then held in the atmosphere on account of the considerably increased exposures of land surfaces and decrease of the sea areas before the Glacial period. During the same time of general continental uplifts, and because of them, volcanic action yielding carbon dioxide was probably somewhat diminished, tending, with the diminution through changed relations of the land and sea, to produce cooler climates over all the earth. Thus a variety of conditions dependent on the great epeirogenic uplifts concurred in causing glaciation.

Conversely, it is seen that during the Champlain epoch, or closing stage of the Glacial period, not only the general depression of the lands beneath their ice burden, but also a concomitant increase of the carbon dioxide in the air, due to reversal of all the former means of its depletion, caused rapid melting and retreat of the ice-sheets.

With the able revision of this edition, it deserves a long continuance of the favor in which it has been held during the past quarter of a century.

W. U.

The Autobiography of Joseph Le Conte. Edited by WILLIAM DALLAM ARMES. Pages 337; with portraits and views from photographs. New York: D. Appleton & Co., 1903.

Within the last year of his life, this veteran geologist, student of Agassiz, South Carolinian through the Civil War, and later for more than thirty years professor in the University of California, prepared a manuscript autobiography for his children, grandchildren, and great grandchildren, to whom from time to time, as his writing advanced, portions of it were read. It is from beginning to end a most interesting life history.

In the final pages, summing up his life work, the following personal estimates are given:

"In Geology, I believe some real substantial advance in science was made in my series of papers; (1) on the structure and origin of mountain ranges; (2) on the genesis of metalliferous veins; (3) especially in that on critical periods in the history of the earth; (4) on the demonstration of the Ozarkian, or, better, the Sierran epoch, as one of great importance in the history of the earth. I might mention several others that I believe are of prime importance, but I am willing to stand by these.

"I look back with especial pleasure on my writings on evolution.... In my lectures in 1872 on Religion and Science, I might be called a reluctant evolutionist....In a few years, however, I was an evolutionist, thorough and enthusiastic....It is, indeed, glad tidings of great joy which shall be to all peoples. Woe is me, if I preach not the Gospel. Lit

erally, it can be shown that all the apparent irreligious and materialistic implications of science are reversed by this last child of science, or rather this daughter of the marriage of science and philosophy. During all my life I have striven earnestly to show this. My book on Evolution and its Relation to Religious Thought is the embodiment of the result of these strivings, although I believe that if I wrote it again I could add much to the argument. I began this line of thought in 1871, and believe, and therefore claim, that I was the pioneer in this reaction against the materialistic and irreligious implication of the doctrine of evolution. I look with greater pleasure on this than on anything else that I have done."

W. U.

MONTHLY AUTHOR'S CATALOGUE

OF AMERICAN GEOLOGICAL LITERATURE ARRANGED ALPHABETICALLY.

ANDERSON, TEMPEST (and JOHN S. KEET).

Preliminary report on the recent eruption of the Soufrière in St Vincent, and of a visit to Mont Pelée in Martinique. (Smith. Inst., Ann. Rep., 1902, pp. 309-330; Reprint from Proc. Roy. Soc. London, Vol. 70).

BAILEY, J. F.

Ore Deposits of Contact, Nevada. (Eng. Mining Jour., Vol. 71, No. 17, p. 612, Oct. 24, 1903).

BROOKS, A. H.

An Exploration to Mount McKinley, America's highest Mountain. (Jour. Geog., Vol. 2, No. 9, Nov. 1903).

CLARKE, C. H.

Notes on the Michipicoten Gold Belt. (Eng. Mining Jour., Vol. 76, No. 20, p. 735, Nov. 14, 1903.)

CLAYPOLE, E. W.

The Devonian Era in the Ohio Basin (continued). Am. Geol., Vol. 32, No. 5, pp. 312-323, Nov., 1903).

DENNY, G. A.

The Witwatersrand Ore Deposits. (Eng. M[illegible] 18, pp. 658-659, Oct. 31, 1903).

ELLIS, MARY.

Index to Publications of the New York [illegible] Survey and New York State Museum 18[illegible] Mus. Bull. 66. Misc. 2. pp. 652, 1903).

EMERSON, B. K. (and JOS. H. PERRY).

The Geology of Worcester, Massachusetts, [illegible] map, index, 1903.

FARIBAULT, E. R.

Deep Gold Mining in Nova Scotia. (Can. Geol. [illegible] 1902).

PERSONAL AND SCIENTIFIC NEWS.

SOME GEOLOGISTS USE THE TERM "glacial ice." It is apparently as tautological as to use the term *black blackbird.*

MR. JOHN HAYS HAMMOND has given $50,000 to the Sheffield Scientific school of Yale University for a laboratory of mining.

THE LATE AMERICAN MINING CONGRESS at Deadwood adjourned to meet in 1904 at Portland, Oregon. The president is J. H. Richards of Boise, Idaho, and the secretary is Irwin Mahon, of Carlisle, Pa.

THE BRADLEY GEOLOGICAL FIELD STATION, at Graydon Springs, Missouri, was opened under the auspices of the Drury College Scientific Association, Oct. 19. Addresses were given by Dr. E. R. Buckley, Dr. William Trelease, Dr. E. M. Shepard, and by the president of Drury college, Dr. Homer T. Fuller.

IT IS PROPOSED BY THE CHIEF OF MINES AND METALLURGY of the St. Louis Exposition that in the exhibits of the various states not only shall the ores and their values be fully represented by characteristic specimens, but that they shall be accompanied by samples of the country rock. Thus the mining experts will be able to compare the surroundings of the great mines of one state with those of characteristic mines of other states.

DR. E. O. HOVEY gave a lecture before the New York Academy of Sciences on the eruptions of Mont Pelée in 1902 and 1903. He sketched the principal events in the volcanic history of the island during the past year and a half. He described the phenomena of the eruptions, the mud-torrents and mud-flows, the attendant and subsequent aqueous erosion on the slopes of the mountain, the rise and vicissitudes of the new cone of eruption and its wonderful spine or obelisk. The lecture was illustrated with about ninety-five lantern slides from negatives taken by the author on the two expeditions which he has made to Martinique for the American Museum of Natural History since the eruptions began.

GEOLOGICAL SOCIETY OF AMERICA. The next meeting will be held at St. Louis, Mo., beginning Dec. 30. The American Association for the Advancement of Science meets at the same place Dec. 28. The Cordilleran section of the Society will meet Jan. 1, 1904, at the rooms of the California Academy of Sciences, San Francisco. The president of the Society is S. F. Emmons, of Washington, and of Section E of the Association, professor I. C. Russell of Ann Arbor.

INDEX TO VOL. XXXII.

Errata for Volume XXXI.

On p. 249, line 7, for "lately" read later.
On p. 250, line 5 from the bottom for "elastic" read clastic.
On p. 182, line 15 from the bottom, for "destiny" read density.
On p. 305, line 19 from the bottom, for "recent" read early.
On p. 361, line 4 from the bottom, for "Boohour" read Barbour.

Errata for Volume XXXII.

On page 52, under *Belgare*: "porphyre" should be porphyry. Under Scotare: "melilyte" should be melilite; "periodyte" should be peridotyte. Under *Hispanare, Atlantare,* and *Austrare*: "Pantellaryte should be pantellerytc. Under *Sverigare*: "Ilmenyte" should be ilmenite; "melilyte" should be melilite. Under *Nogare*: "Solvsberg should be solvsbergyte; "borolonyte" should be borolanite. Under *Portugare*: "Essexote" should be essexyte; "nephclinyte" should be nephelinyte. Under *Bohemare*: "Lecuityte" should be leucityte; "melilyte" should be melilite.

On p. 133, line 2 from the bottom, for "Lesley and family" read Lesley's family.

On p. 134, line 15, for "his" read its.

On p. 135, line 17 from the bottom, for "duties" read duty.

On p. 162, line 14, for "glacio-fluvitile" read glacio-fluviatile.

On p. 163, line 8 from bottom, for "geneissic" read gneissic.

On p. 163, line 7 from bottom, for "corrosion" read corrasion.

On p. 168, line 4, for "force-set" read fore-set.

On p. 179, last line, strike out "of diction," and line 10, for "one read a.

On p. 178, line 19 from the bottom, strike out "a" and for "its" read their.

On p. 180, line 12 from the bottom, for "expressive" and "appeals' read expression and appeal; and line 13 from the bottom, read Alpine

On p. 181, line 7, after "in" insert a.

On p. 334, line 3 from the bottom, for "monzanite" read monazite

ECEMBER, 1903. VOL. XXXII, NO. 6.

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